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On the Atomic Weight of Gallium

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(December 20, 1976)

Accurate measurement of stoichiometry of GaAs provides new data which are used for calculation of the atomic weight of Ga. Using the IUPAC accepted value for the atomic weight of As (74.9216), the atomic weight of Ga based on this work is 69.737 ± 0.006. The mean of two independent chemical values for the atomic weight of Ga, one obtained by Lundell and Hoffman and the other in this work, is 69.735.

Key words: Atomic weight; coulometry; electrochemical equivalent; gallium arsenide; gallium atomic weight; stoichiometry.

1. Introduction

The presently accepted value of the atomic weight of gallium is 69.72 [1].[1] This value is based primarily on the work of Richards and Craig [2, 3] involving preparation of gallium trichloride with subsequent determination of $GaCl_3$/3Ag ratio, conversion of gallium metal to gallium oxide via several routes by Lundell and Hoffman [4] and mass spectrometric determination of $^{69}Ga/^{71}Ga$ ratio by Inghram, et al. [5]. It is interesting that the "rounded value" of the atomic weight of Ga as reported by Lundell and Hoffman [4] is 69.74 which differs significantly from 69.716, the value obtained on the basis $GaCl_3$/3Ag ratio and from the mass spectrometric value of 69.72.

The establishment of atomic weights has never been easy in view of high demands on accuracy and the need for many independent methods of determining these "constants." In some cases the values based on the mean of many measurements were found to agree quite well with the data obtained by new methods and instrumentation used for such purposes. Such is the case with potassium, for which the newly determined atomic weight by means of absolute mass spectrometric isotopic abundance measurement [6] is in excellent agreement with the atomic weight of potassium based on chemical intercomparison data [7].

DeLaeter recently reported a mass-spectrometrically measured $^{71}Ga/^{69}Ga$ ratio as 0.6559 [8]. The mass spectrometer used in this work produces isotope fractionation, resulting in the apparent lighter isotope (^{69}Ga) enrichment. The magnitude of this effect, as measured by DeLaeter from $^{87}Rb/^{85}Rb$ for the National Bureau of Standards rubidium reference material SRM 984, is 0.625 percent per mass unit difference. Thus applying an overall fractionation correction of 1.25 percent to gallium isotope ratio the corrected value was reported as 0.6641. This ratio, in turn, when combined with isotopic mass data [9], yields 69.724 as the atomic weight of gallium.

Coulometry, by no means a new method, has been used for accurate determination of atomic weights as recently as 1975 [10, 11], and as a method of preference for the assay of the separated isotope solutions for absolute calibration of mass spectrometers, used in atomic weight determinations [12, 13, 14, 15]. In this paper data are reported which were obtained as part of a different experiment, namely the evaluation of the stoichiometry of a compound, through the determination of major constituents. These data on coulometric determinations of stoichiometry of GaAs shed some additional light on the atomic weight of Ga.

2. Material

As part of a chemical characterization exchange program under the auspices of OECD (Organization for Economic Cooperation and Development), characterization of high purity, specially prepared single crystal gallium arsenide was one of the problems of interest [16]. The material had been prepared by a state-of-the-art procedure to produce single crystals of high purity and accurate stoichiometry. The determination of impurities in this material by other methods indicates that it is of extremely high purity. For the purpose at hand even 99.995 percent purity would have been acceptable, but of course the material used is of higher purity. For example, mass spectrometric determination of impurities indicates that by difference gallium and arsenic comprise 99.9993 weight percent of this material, while neutron activation determination of impurities indicates that gallium and arsenic constitute 99.9994 weight percent [16].

Four different samples of single crystal GaAs were investigated. Samples, weighing on the average 320 mg, were removed from their plastic packaging, placed on a porcelain plate and divided approximately in half by applying moderate pressure with a steel knife along the cleavage plane of the crystal. Subsequently each piece was etched in a platinum crucible using ACS reagent-grade HF, washed in distilled water and vacuum dried in a desiccator as specified in the OECD instructions under deoxygenation procedure. Each piece was placed in a platinum boat, weighed and delivered carefully into a previously washed and dried 125 ml Erlen-

[1] Figures in brackets indicate the literature references at the end of this paper.

meyer flask. Five milliliters of "Suprapure" nitric acid were delivered into the flask in a hood, the flask was inclined so that it was virtually horizontal, to prevent the loss of spray, and left in that position until dissolution of the sample was complete.

3. Method

3.1 General Description

The general classification of the method is constant current coulometric titration with amperometric end-point determination. Since this study involved the determination of GaAs stoichiometry obviously two methods were used: one for Ga and one for As. Gallium was determined via an EDTA (ethylenediamine tetraacetic acid) complexation reaction and back titration of excess EDTA with zinc. In general, the analytical procedure of Reilley et al. was adopted [17]. Reilley et al. have shown that gallium can be determined volumetrically with precision and accuracy better than 0.05 percent. The coulometric procedure, enabling even more accurate quantitation, was developed in this laboratory. With the exception of the reduction procedure arsenic determination was based on our earlier work [18].

Reilley's procedure for the determination of gallium requires standard EDTA and standard zinc solutions. Excess EDTA was added to complex the trivalent gallium (in acetate buffer solution), heated, and the excess EDTA was back titrated with standard zinc solution. A small amount of mercuric EDTA complex was added to the solution to act as an indicator ion, using a mercury indicator electrode.

In our method, EDTA was handled as a solid. It was standardized coulometrically with electrogenerated Zn^{++}. The electrochemical behavior of Zn (Hg) was reported earlier [8, 9]. The end-point of this titration was determined amperometrically using a gold amalgam polarizable electrode, a standard calomel reference electrode and an applied potential of 1.20 V versus SCE (saturated colomel electrode). This potential corresponds to the diffusion plateau of the Zn^{++} reduction wave.

3.2 Coulometric Standardization of EDTA

In order to proceed with determinations of gallium via the EDTA titration, it is necessary to know the "complexometric titer" of EDTA. It was, therefore, decided to determine the electrochemical equivalent of a small lot of $Na_2EDTA \cdot 2H_2O$ for this purpose. The material (about 500 g) was stored in a 52 percent relative humidity atmosphere (over saturated $Mg(NO_3)_2$ solution). A two gram sample of the material was used for each determination. After weighing EDTA samples by substitution they were delivered into 125 ml Erlenmeyer flasks.

After deaeration of the electrolyte (0.5 M NaCl + 0.5 M sodium acetate) a small amount of EDTA (e.g. 30 μeq) was added to the anode compartment and the electrolyte was pretitrated with electrogenerated Zn^{++} to an amperometric end point. The electrolyte was then permitted to flow into the intermediate compartments of the cell and also drawn into the Erlenmeyer flask (equipped with siphon arrangement) containing the weighed EDTA sample. The sample was dissolved and forced into the cell. Subsequently, sufficient Zn^{++} was generated at 100 mA to react with about 99.8 percent of the calculated amount of EDTA in the sample. The passage of current through the cell was then stopped. The Erlenmeyer flask, which originally contained the sample, was rinsed by repeated filling and emptying of the electrolyte from the cell, and the intermediate cell compartments were rinsed by appropriate manipulation of the vacuum and nitrogen lines, leaving only a small amount of electrolyte on the bottom of these compartments to permit the passage of low current. Then the titration was resumed. At this stage, just as in pretitration, the titration was carried out at 6.43 mA current. An argon stream was bubbled through the solution and the indicator current was measured after the passage of each increment of charge (1 μeq of Zn^{++}). After the completion of the data acquisition in the end-point region and beyond it, the two linear portions of the indicator current (residual current and the limiting current due to the reduction wave of Zn^{++}) were extrapolated graphically to the point of intersection. Since the indicator current exhibits a significant curvature in the end-point region and the slopes of the indicator current lines are not very reproducible, such an extrapolation could cause some significant errors. Consequently, the point of maximum change in the slope of the indicator current function was approximated by bisection of the angle between the residual current and Zn^{++} limiting current lines and extrapolation of the bisector to the fitted curvature.

3.3 Gallium Determination

The solution of gallium arsenide in nitric acid was evaporated down to virtual dryness, converted to sulfate using 10 ml of water and 1 ml of concentrated ACS reagent grade sulfuric acid, and evaporated down. Ten milliliters of concentrated HCl and 2 ml of H_2SO_3 were added and volatilization of $AsCl_3$ was carried out on a hot plate at about 80 ° C. H_2SO_3 was added two more times and the heating process was continued for a total time of 4 hours. After cooling the solution, NH_4OH was added dropwise until a precipitate of gallium hydroxide became permanent. An excess of previously standardized $Na_2EDTA \cdot 2H_2O$ was weighed into the flask via a powder funnel and washed down with about about 50 ml of pretitrated supporting electrolyte (0.5 M NaCl and 0.5 M sodium acetate; pH = 5.5). The solution was heated for an hour at about 50 ° C on a hot plate, cooled and delivered into a coulometric cell containing 50 ml of pretitrated supporting electrolyte. Subsequently, the excess EDTA (that amount which did not react with Ga^{+++}) was back titrated with electrogenerated Zn^{++}, generated coulometrically from the Zn-amalgam anode. The end point was determined amperometrically in the same manner as in the standardization of EDTA. An argon atmosphere was maintained in the cell in the course of the whole experiment.

3.4 Arsenic Determination

The sample, pretreated and weighed in the same manner as for the Ga determination, was dissolved in a 125 ml Erlenmeyer flask in 5 ml of concentrated HNO_3. The excess HNO_3 was removed by the addition of 1 ml of H_2SO_4 and triple evaporation. The pentavalent arsenic was reduced with 5 ml of H_2SO_3. The excess SO_2 was removed by sweeping the flask with nitrogen for one hour. The solution, neutralized

with deaerated 1 M NaOH until precipitation of $Ga(OH)_3$ became apparent, was delivered via the siphon arrangement into the pretitrated electrolyte (0.1 M KI + saturated solution of $NaHCO_3$; pH = 7.0). Titration to the amperometric end point was carried out as described earlier [15]. An argon atmosphere was maintained in the cell.

4. Instrumentation[2]

For constant-current coulometric titrations, three different instrumental facilities are required for the measurements of current, time and end-point indicator signal.

4.1. Current

A Princeton Applied Research constant-current power supply Model TC602-CR was employed. Its maximum output is 60V and its current rating is 2A. The power supply was operated in a constant-current mode. The current value was selected to be such that the IR drop across the standard resistor equals the voltage of the saturated Weston cell. The standard resistor and Weston cells were calibrated at NBS.

4.2. Time

A Beckman Model 3750 Universal EPUT and Timer was used for measuring the time interval between the start and termination of the passage of current through the coulometric cell.

4.3. End-Point Determination

A Sargent Model XXI polarograph was used for application of the potential to the indicator electrode system and for recording the indicator current.

4.4. Mass Measurement

A Mettler Microbalance was used for weighing. The balance is a constant load type, 20-g capacity. The standard deviation of the mass measurement process on this balance, established over a number of years, is 0.003 mg. The samples were weighed in a platinum boat by the substitution method. NBS calibrated weights were used for this purpose. The weight of the samples was corrected to the mass in vacuum by applying the appropriate corrections for the effect of air buoyancy.

4.5. Method of Calibration

The electrical and time measurements were performed against standards calibrated by the appropriate laboratories of the NBS. The accurate current measurement was based on the values of a standard resistor and the voltage of a saturated Weston cell.

[2] Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately specify the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the material or equipment identified is necessarily the best available for the purpose.

5. Results

The most direct way of examining the result of stoichiometric determinations is to view them in terms of the number of moles of constituent elements per unit weight of material. Thus, the results of analysis of single crystal GaAs, reported in terms of millimoles of Ga and As per gram of GaAs, are summarized in table 1. The analyses performed show that the analyzed material adheres closely to 1:1 compound stoichiometry. It is important to note here that the determination of stoichiometry through coulometric analysis is totally independent of the knowledge of the atomic weights of the analyzed constituents; for that matter it is independent from most of the constants which are involved in computations (e.g., Faraday's constant). All known possible systematic errors are believed to be negligible.

TABLE 1. *Coulometric Analysis of* GaAs

Ga, mM/g GaAs	As, mM/g GaAs
6.91291	6.91325
6.91324	6.91283
6.91244	6.91276
6.91269	6.91259
Ave. 6.91282	Ave. 6.91286
S = 0.00034	S = 0.00028
Overall Average = 6.91284	
Pooled standard deviation = 0.00031	
Standard error of overall average = 0.00011	

Using the stoichiometry data of table 1 and invoking the accepted value for the atomic weight of arsenic (74.9216) the pooled data, reported in table 2, were calculated. The rationale behind the use of pooled data is that no apparent significant difference is found between the molar gallium and arsenic content of the analyzed material. Hence, for 1:1 stoichiometric compound, pooling the molar content values is justifiable and used as the basis for the calculations of the atomic weight of gallium.

TABLE 2. *Pooled Data* [a]

As	51.7921 percent by weight
Ga	48.2079 percent by weight
Atomic weight of Ga = 69.737 ± 0.006	

[a] These data are based on the pooled stoichiometry data of Table 1 and 74.9216 as the atomic weight of arsenic. The uncertainty indicated is the 95 percent confidence limit.

Thus, using 74.9216 as the atomic weight of arsenic its concentration in GaAs is found to be 51.7921 percent by weight. Since concentration of impurities in this material was found to be negligibly small, the concentration of gallium can be easily calculated to be 48.2079 percent by weight (as the difference from 100.0000 percent). Hence on the basis of data reported here the atomic weight of gallium is 69.737 ± 0.006, the uncertainty being the 95 percent confidence limit.

6. Conclusions

Coulometrically determined concentrations of Ga and As in GaAs confirm a high degree of adherence of the analyzed material to 1:1 compound stoichiometry. The value of the atomic weight of Ga (69.737) computed from data reported here differs somewhat from the IUPAC accepted value of the atomic weight of gallium (69.72) and is believed to be more accurate. It should be noted that this is the first attempt to use GaAs as the material for atomic weight determination. The electrochemical value of the atomic weight of Ga computed here is in a good agreement with the chemical combining weight ratio value obtained by Lundell and Hoffman [4], based on gallium-to-oxygen-weight-ratio in Ga_2O_3. Using the two independent values for the atomic weight of Ga (one based on this work and one based on the data of Lundell and Hoffman [4]) the mean chemical value of the atomic weight of Ga based on its compound stoichiometry is 69.735.

It appears that two distinctly different values of the atomic weight of gallium are now in existence. The mass spectrometric value is 69.724 and the chemical value is 69.735. In view of the fact that no significant gallium isotope fractionations are reported in nature, the likelihood of isotope fractionation in the purification of GaAs is highly remote. This apparent discrepancy needs to be resolved. Determination of the atomic weight of gallium coulometrically by another independent approach, similar to that used for the atomic weight of zinc [10, 11], is anticipated in this laboratory. The use of high purity gallium will eliminate a possible source of error in chemical determination of atomic weights, namely that of compound stoichiometry.

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Vapor Pressure Formulation for Ice

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A new formulation is presented for the vapor pressure of ice from the triple point to −100 °C based on thermodynamic calculations. Use is made of the definitive experimental value of the vapor pressure of water at its triple point recently obtained by Guildner, Johnson, and Jones. A table is given of the vapor pressure as a function of temperature at 0.1-degree intervals over the range 0 to −100 °C, together with the values of the temperature derivative at 1-degree intervals. The formulation is compared with published experimental measurements and vapor pressure equations. It is estimated that this formulation predicts the vapor pressure of ice with an overall uncertainty that varies from 0.016 percent at the triple point to 0.50 percent at −100 °C.

Key words: Clausius-Clapeyron equation; saturation vapor pressure over ice; thermal properties of ice; vapor pressure; vapor pressure at the triple point; vapor pressure of ice; water vapor.

1. Introduction

In meteorology, air conditioning, and hygrometry, particularly in the maintenance and use of standards and generators in calibrations and in precision measurements, accurate values of the vapor pressure of the pure water-substance are essential. Because of this Wexler and Greenspan [1][1] recently published a new vapor pressure formulation for the pure liquid phase, based on thermodynamic calculations, which is in excellent agreement from 25 to 100 °C with the precise measurements of Stimson [2]. Wexler [3] subsequently revised this formulation to make it consistent with the definitive experimental value of the vapor pressure of water at its triple point obtained by Guildner, Johnson, and Jones. The purpose of this present paper is to apply a similar method of calculation to the pure ice phase and derive a new formulation for temperatures down to −100 °C. This new formulation for ice is constrained to yield the identical value of vapor pressure at the triple point as that given by the revised formulation for the liquid phase.

A critical examination of the experimental vapor-pressure data of ice discloses the disconcerting fact that the dispersion among those values far exceeds modern accuracy requirements. This dispersion arises, in part, from the inherent difficulties experienced by investigators in making precision measurements of these low pressures and from the ambiguities in the temperature scale used in the early 1900's when several major series of determinations were made. Thermodynamic calculations, based on accurate thermal data, provide an alternate route to the determination of vapor pressure. It is therefore not surprising that such calculations have been made repeatedly for ice with varying degrees of success. It is interesting to note that these calculations have been preferred over the existent experimental vapor pressures, primarily because the calculations appear to yield less uncertainty than the measurements.

[1] Figures in brackets indicate the literature references at the end of this paper.

2. Derivation

The Clausius-Clapeyron equation, when applied to the solid-vapor phase transition for the pure water-substance, may be written

$$\frac{dp}{dT} = \frac{l}{T(v - v'')} \tag{1}$$

where p is the pressure of the saturated vapor, v is the specific volume of the saturated vapor, v'' is the specific volume of the saturated ice, T is the absolute thermodynamic temperature, l is the latent heat of sublimation, and dp/dT is the derivative of the vapor pressure with respect to temperature. The latent heat of sublimation is given by

$$l = h - h'' \tag{2}$$

where h is the specific enthalpy of saturated water vapor at temperature T and h'' is the specific enthalpy of saturated ice at the same temperature T.

The equation of state for saturated water vapor may be expressed by

$$pv = ZRT \tag{3}$$

where Z is the compressibility factor and R is the specific gas constant. When eq (3) is substituted into eq (1) the result is

$$\frac{dp}{p} = \frac{l}{ZRT^2}\left(1 + \frac{v''}{v}\right) dT \tag{4}$$

where higher order terms of v''/v are neglected because $v''/v \ll 1$. On integrating, eq (4) becomes

$$\int_{p_1}^{p_2} d(\ln p) = \int_{T_1}^{T_2} \frac{l}{ZRT^2}\left(1 + \frac{v''}{v}\right) dT \tag{5}$$

where p_1 and p_2 are the saturation vapor pressures at temperatures T_1 and T_2, respectively. Suitable functions will be sought for Z, v, v'' and l in order to complete the integration of eq (5).

Functions for the compressibility factor Z and the specific volume of saturated water vapor v will be based on a virial equation of state expressed as a power series in p. A function for the specific volume of saturated ice v'' will be developed from experimental data for the coefficient of linear expansion and the density at 0 °C. A function for the latent heat of sublimation l will be derived from the specific enthalpies h'' and h of saturated ice and saturated water vapor, respectively. Use will be made of measurements of the specific heat of ice to obtain h'' whereas statistical mechanical calculations of the ideal-gas (zero-pressure) specific heat of water will serve as input data for establishing an expression for h.

2.1 Temperature

Guildner and Edsinger [5] have recently made measurements on the realization of the thermodynamic temperature scale from 273.16 to 730 K by means of gas thermometry. Unfortunately there are no similar high precision measurements below 273.16 K. Therefore, it will be assumed that the International Practical Temperature Scale of 1968 (IPTS-68) [6] is a sufficiently close approximation to the absolute thermodynamic temperature so that the thermal quantities given in terms of IPTS-68 can be used in eq (5). From the triple point to −100 °C the temperature t in degrees Celsius has the same numerical values on the International Temperature Scale of 1927 (ITS-27) [7], the International Temperature Scale of 1948 (ITS-48) [8] and the International Practical Temperature Scale of 1948 (IPTS-48) [9]. However, the ice point on IPTS-48 is defined as equal to 273.15 kelvins whereas on ITS-27 and ITS-48 it is defined as equal to 273.16 kelvins. The difference $T_{68} - T_{48}$, where T_{68} and T_{48} are the kelvin temperatures on IPTS-68 and IPTS-48, respectively, in the range of interest reaches a maximum of 0.0336 kelvin at 200 K [10, 11]. Using the corrections given by Riddle, Furukawa, and Plumb [11], temperatures on ITS-27, ITS-48 and IPTS-48 have been converted to IPTS-68 where needed in the calculations.

2.2. Specific Volume of Saturated Vapor

Equation (3) is used to calculate the specific volume of saturated water vapor v. The compressibility factor Z is expressed as a power series in p

$$Z = 1 + B'p + C'p^2 + \cdots \qquad (6)$$

where B' is the second pressure-series virial coefficient and C' is the third pressure-series virial coefficient. The contribution of $C'p^2$ to Z is only a few parts per million at the triple point and less at lower temperatures and so has negligible effect. The empirical relationship for the second virial coefficient is based on experimental data obtained at elevated temperatures. This equation will be extrapolated below 0 °C with the full recognition that this may lead to large uncertainties in the virial coefficients. Although B' rapidly increases in magnitude with decreasing temperature, the saturation vapor pressure decreases even more rapidly so that Z rapidly approaches its limiting value of unity as the temperature drops. Saturated water vapor, therefore, tends to behave more and more like an ideal gas as the temperature decreases, thereby reducing the effect of errors in B'.

Table 1 shows a comparison of Z from the triple point to −100 °C, for water vapor saturated with respect to ice, calculated using the empirical second virial coefficient equations of Goff and Gratch [12, 13, 14], Keyes [15, 16], and Juza as given by Bain [17]. The maximum difference in Z, as well as v, is 118 ppm and occurs at 0.01 °C. This can be used as an indication of uncertainty although the actual error is indeterminate. The differences decrease as the temperature decreases. At −70 °C and below, the differences are equal to, or less than, one ppm since, at such temperatures, the second virial coefficient makes a negligible contribution to Z.

TABLE 1. *Compressibility factor for saturated water vapor over ice*

Temperature	Compressibility Factor[a]			
°C	Keyes 1969[b] Z	Keyes 1947[c] Z	Bain[d] Z	Goff and Gratch[e] Z
0.01	0.999624	0.999501	0.999529	0.999506
0	.999624	.999501	.999529	.999506
−10	.999907	.999726	.999747	.999730
−20	.999958	.999856	.999871	.999859
−30	.999982	.999928	.999938	.999930
−40	.999993	.999966	.999972	.999967
−50	.999998	.999984	.999986	.999985
−60	.999999	.999994	.999996	.999994
−70	1.000000	.999997	.999999	.999998
−80	1.000000	.999999	1.000000	.999999
−90	1.000000	1.000000	1.000000	1.000000
−100	1.000000	1.000000	1.000000	1.000000

[a] Calculated by eq (6) using B' given by the indicated investigator.
[b] Ref [16].
[c] Ref [15].
[d] Ref [17].
[e] Ref [12–14].

The 1969 second virial coefficient of Keyes [16] will be used in order to be consistent with the earlier use of this same coefficient [3]. His virial coefficient equation, converted to SI units compatible with eq (6), is

$$B' = \left[\frac{0.44687}{T} - \left(\frac{565.965}{T^2}\right) \times 10^{\frac{100800}{34900 + T^2}}\right] \times 10^{-5}. \qquad (7)$$

where B' is in units of reciprocal pressure $(\text{Pa})^{-1}$.[2]

2.3. Specific Volume of Saturated Ice

Only hexagonal Ice-I will be of concern. It will be assumed that the crystals are randomly aligned with respect to the optic axis. All known measurements of the density of ice have been made in the presence of an inert gas, usually at a pressure of one atmosphere and at a temperature of 0 °C.

[2] 1 Pa = 1 N/m² = 10^{-5} bar = 10^{-2} mb = 7.50062 × 10^{-3} mm Hg.

Dorsey [18] has compiled an extensive list of such determinations. Ginnings and Corruccini [19] using a Bunsen ice calorimeter, obtained a value at 0 °C and one atmosphere[3] of 0.91671 g/ml. This value is definitive and supersedes all earlier measurements. Using this value and the coefficient of linear expansion of ice, the specific volume was calculated at temperatures below 0 °C as follows.

The isopiestic coefficient of linear expansion of ice α_P is defined by the equation

$$\alpha_P = \left(\frac{1}{\lambda_i}\frac{d\lambda}{dT}\right)_P \tag{8}$$

where λ_i is the initial length of a specimen at the ice point temperature, λ is the length of the same specimen at temperature T and $d\lambda/dT$ is the rate of thermal expansion. By integrating eq (8), cubing the resultant equation, neglecting higher order terms in $\int_{T_i}^{T} \alpha_P dT$, it follows that

$$v''_{P,T} = v''_{P,T_i}\left[1 + 3\int_{T_i}^{T} \alpha_P\, dT\right] \tag{9}$$

where $v''_{P,T}$ is the specific volume of ice at pressure P and temperature T, v''_{P,T_i} is the specific volume of ice at pressure P and at the ice point temperature T_i.

There are several series of measurements of the coefficient of linear expansion of hexagonal Ice-I at atmospheric pressure. The data of Jakob and Erk [20], Powell [21], Butkovich [22], Dantl [23], and LaPlaca and Post [24] were fitted to a linear equation by the method of least squares. The result is

$$\alpha_{P_a} \times 10^6 = -7.6370 + 0.227097\, T \tag{10}$$

which, when substituted into eq (9) together with the Ginnings and Corruccini value[4] for the density of ice at 0 °C and one atmosphere becomes

$$v''_{P_a,T} = 1.069989 - 0.249933 \times 10^{-4}\, T + 0.371606 \times 10^{-6}\, T^2 \tag{11}$$

where $v''_{P_a,T}$, expressed in cm^3/g, is the specific volume at atmospheric pressure, i.e., 101325 Pa, and temperature T. It is the specific volume at saturation rather than at atmospheric pressure that is needed. The specific volume at a given pressure can be corrected to that at another pressure from a knowledge of the isothermal compressibility k, which is given by the equation

$$k = k_s + \frac{Tv''\beta^2}{c''_P} \tag{12}$$

where k_s is the adiabatic compressibility, T is the absolute temperature, v'' is the specific volume, β is the volume expansivity, and c''_P is the specific heat at constant pressure. Values of the isothermal compressibility of ice were calculated by using Leadbetter's values [27] for the adiabatic compressibility of Ice-I, eq (11) to obtain the specific volume at pressure P_a and temperature T, eq (10) to obtain β ($= 3\alpha_{P_a}$), and eq (19) (which is derived later) to obtain the specific heat at constant pressure P_a. The results for the temperature range of interest are given by the linear equation

$$k = (8.875 + 0.01657T) \times 10^{-11} \tag{13}$$

where k is expressed in units of $(Pa)^{-1}$. The specific volume of ice at pressure P and temperature T is therefore $v''_{P,T} = v''_{P_a,T}[1 - k(P - P_a)]$ so that

$$v''_{P,T} = v''_{P_a,T}[1 - (8.875 + 0.01657T)(P - 101325) \times 10^{-11}] \tag{14}$$

where P is expressed in Pa. If the saturated vapor pressure p is inserted for P, then eq (14) yields the pure phase specific volume v'' at saturation. Over the temperature range 173.15 to 273.16 K the numerical value of the bracket is equal to 1.000013 with a maximum variability of one ppm. Using this value yields

$$v''_{P,T} = v'' = 1.070003 - 0.249936 \times 10^{-4}\, T + 0.371611 \times 10^{-6}\, T^2. \tag{15}$$

2.4 Enthalpy of Ice

It can be shown [26] that the specific enthalpy h'' of the solid phase of a pure substance, say ice, is given by the relationship

$$dh'' = c''_P\, dT + v''_T\, dP - T\left(\frac{\partial v''_T}{\partial T}\right)_P dP \tag{16}$$

where c''_P is the specific heat of ice at constant pressure P. When integrated this equation becomes

$$\int_{h''_1}^{h''_2} dh'' = \int_{T_1}^{T_2} c''_P\, dT + \int_{P_1}^{P_2}\left[v'' - T\left(\frac{\partial v''}{\partial T}\right)_P\right]_T dP \tag{17}$$

Because eq (17) represents a system undergoing a reversible process between two equilibrium states, the initial and final enthalpies are independent of the path. Therefore, a path is chosen which starts on the saturation curve at (T_i, p_i), moves isothermally to (T_i, P_a), then proceeds isobarically to (T, P_a), and finally goes isothermally to (T, p). The integration along this path is given by

[3] 1 atmosphere = 101325 pascals.

[4] The density was converted from g/ml to g/cm^3 by using the factor 1 ml = 1.000028 cm^3 [25].

$$h'' - h''_i = \int_{p_i}^{P_a} \left[v'' - T\left(\frac{\partial v''}{\partial T}\right)_{p_i} \right]_{T_i} dP + \int_{p_i}^{T} c''_{P_a}\, dT + \int_{P_a}^{P} \left[v'' - T\left(\frac{\partial v''}{\partial T}\right)_{P_a} \right]_{T} dP. \quad (18)$$

If p_i is the saturation vapor pressure at the ice-point temperature T_i, p is the saturation vapor pressure at temperature T, and P_a is any other pressure, say standard atmospheric pressure, then $h'' - h''_i$ is the difference in specific enthalpy of saturated ice, under its own equilibrium vapor pressure, between temperatures T and T_i.

Although measurements of the isopiestic specific heat of ice have been made by several investigators [28–35], only those of Giauque and Stout [34] will be used because it is believed that these are the best available over the range of temperatures of interest here. These measurements were made at standard atmospheric pressure and cover the temperature range 16.43 to 267.77 K. They are in good agreement with the precise measurements of Dickinson and Osborne [30]. Unfortunately, the latter measurements do not extend below 233.15 K.

Fitting the Giauque and Stout data from 169.42 to 267.77 K to a quadratic equation by the method of least squares with the temperature converted to IPTS-68 and the heat units to joules, yields

$$c''_{P_a} = A_0 + A_1 T + A_2 T^2 \quad (19)$$

where c''_{P_a} is the specific heat in J/gK at a pressure of one atmosphere. The coefficients are given in table 2. Integrating eq (19), one obtains

$$\int_{T_i}^{T} c''_{P_a}\, dT = A_0(T - T_i) + \frac{A_1}{2}(T^2 - T_i^2) + \frac{A_2}{3}(T^3 - T_i^3). \quad (20)$$

By letting

$$\Delta h'' = \int_{p_i}^{P_a} \left[v'' - T\left(\frac{\partial v''}{\partial T}\right)_{p_i} \right]_{T_i} dP + \int_{P_a}^{P} \left[v'' - T\left(\frac{\partial v''}{\partial T}\right)_{P_a} \right]_{T} dP \quad (21)$$

and performing the indicated differentiations and integrations, eq (21) is reduced to the form

$$\Delta h'' = B_0 + B_1 T^2 + B_2 p \quad (22)$$

where p is the saturation vapor pressure in Pa at temperature T, $P_a = 101325$ Pa and $p_i = 611$ Pa. The coefficients are given in table 2. Substitution of eqs (20) and (22) into (18) yields

$$h'' = h''_i + A_0(T - T_i) + \frac{A_1}{2}(T^2 - T_i^2) + \frac{A_2}{3}(T^3 - T_i^3) + \Delta h''. \quad (23)$$

A numerical value remains to be assigned to the reference enthalpy h''_i. At any specified temperature T, the latent heat of fusion of ice l'' is given by

$$l'' = h' - h'' \quad (24)$$

where h' and h'' are the specific enthalpies of liquid water and ice, respectively. By adopting the convention $h'_i = 0$ at the ice-point temperature it follows that $l''_i = -h''_i$. The choice of this convention will not effect the final results because the arbitrary assignment will cancel out in the computations. Use is now made of the experimentally determined value for the latent heat of fusion of ice at 0 °C and standard atmospheric pressure recommended by Osborne [36][5], namely, 333.535 J/g. By means of the thermodynamic relationship

$$\left(\frac{\partial h}{\partial P}\right)_T = v - T\left(\frac{dv}{dT}\right)_P \quad (25)$$

the latent heat was adjusted from standard atmospheric pressure (101325 Pa) to the saturation vapor pressure of ice at 0 °C, i.e., 611 Pa, yielding $l''_i = -h''_i = 333.430$ J/g. Equation (23) therefore becomes

$$h'' = -l''_i + A_0(T - T_i) + \frac{A_1}{2}(T^2 - T_i^2) + \frac{A_2}{3}(T^3 - T_i^3) + \Delta h'' \quad (26)$$

2.5. Enthalpy of Water Vapor

From eqs (3) and (6) it follows that

$$v = \frac{RT}{p}(1 + B'p + C'p^2 + \cdots) \quad (27)$$

and

$$\left(\frac{\partial v}{\partial T}\right)_p = \frac{R}{p}(1 + B'p + C'p^2 + \cdots) + \frac{RT}{p}\left(p\frac{\partial B'}{\partial T} + p^2\frac{\partial C'}{\partial T} + \cdots\right) \quad (28)$$

which on substitution into eq (25) yield

$$\left(\frac{\partial h}{\partial p}\right)_T = -RT^2\left[\frac{\partial B'}{\partial T} + p\frac{\partial C'}{\partial T} + \cdots\right]. \quad (29)$$

Integration with respect to p leads to

$$h_{p,T} = h_{p_0,T} - RT^2\frac{\partial B'}{\partial T}p - \frac{1}{2}RT^2\frac{\partial C'}{\partial T}p^2 - \cdots \quad (30)$$

[5] The value given by Osborne was converted from international joules to absolute joules by the factor 1.000165 J = 1 i.j.

where $h_{p,T}$ is the enthalpy of water vapor at saturation pressure p and temperature T and $h_{p_0,T}$ is the ideal-gas (zero-pressure) specific enthalpy at the same temperature T. The third and higher-order terms will be ignored because their contributions to $h_{p,T}$ are negligible. Thus, by setting

$$\Delta h = RT^2 \frac{\partial B'}{\partial T} p \tag{31}$$

the result can be written

$$h_{p,T} = h_{p_0,T} - \Delta h. \tag{32}$$

Friedman and Haar [37] have calculated the ideal-gas (zero-pressure) specific heat c_{p_0}/R for water vapor from statistical mechanical considerations over a wide range of temperatures. Their calculated values from 170 to 280 K were fitted to a polynomial equation by the method of least squares which, after multiplying by R, has the form

$$c_{p_0} = D_0 + D_1 T + D_2 T^2 + D_3 T^3 \tag{33}$$

in units of J/gK. The coefficients are given in table 2. Integrating with respect to temperature from the ice point temperature T_i to T, one gets

$$h_{p_0,T} - h_{p_0,T_i} = \int_{T_i}^{T} c_{p_0}\, dT \tag{34}$$

which becomes

$$h_{p_0,T} - h_{p_0,T_i} = D_0(T - T_i) + \frac{D_1}{2}(T^2 - T_i^2) + \frac{D_2}{3}(T^3 - T_i^3) + \frac{D_3}{4}(T^4 - T_i^4) \tag{35}$$

where $h_{p_0,T}$ and h_{p_0,T_i} are the ideal-gas (zero-pressure) specific enthalpies of water vapor at temperatures T and T_i in units of J/g.

The ideal gas specific enthalphy h_{p_0,T_i} is a constant to which a numerical value must be assigned. In order to do so use is made of the latent heat of vaporization l' at the ice point. By definition

$$l' = h - h'. \tag{36}$$

It will be recalled that the convention that $h'_i = 0$ at the ice point has already been adopted. Hence at this temperature $h_i = l'_i$, with the result that eq (32) becomes

$$h_i = h_{p_0,T_i} - \Delta h_i \tag{37}$$

where

$$\Delta h_i = RT_i^2 \frac{\partial B'}{\partial T} p_i. \tag{38}$$

Replacing h_i by l'_i in eq (37), one obtains

$$h_{p_0,T_i} = l'_i + \Delta h_i. \tag{39}$$

Substituting eq (39) into eq (35) gives rise to an expression for the ideal-gas specific enthalpy of water vapor, that is,

$$h_{p_0,T} = l'_i + \Delta h_i + D_0(T - T_i) + \frac{D_1}{2}(T^2 - T_i^2) + \frac{D_2}{3}(T^3 - T_i^3) + \frac{D_3}{4}(T^4 - T_i^4). \tag{40}$$

Now by inserting eq (40) into (32) the real-gas specific enthalpy of saturated water vapor ensue, namely,

$$h = h_{p,T} = l'_i + \Delta h_i - \Delta h + D_0(T - T_i) + \frac{D_1}{2}(T^2 - T_i^2) + \frac{D_2}{3}(T^3 - T_i^3) + \frac{D_3}{4}(T^4 - T_i^4) \tag{41}$$

To calculate l'_i, use is made of an approach due to Osborne [38] which starts with the definition of an experimentally measured calorimetric quantity γ

$$l' = \gamma - \delta. \tag{42}$$

γ has been quite accurately measured [38-41]. δ is given by [38]

$$\delta = \left(\frac{v'}{v - v'}\right) l' = v'T \frac{dp}{dT} \tag{43}$$

TABLE 2. *Coefficients to equations*

	j					
	0	1	2	3	4	5
A	0.274292	0.582109×10^{-2}	0.325031×10^{-5}			
B	-0.344×10^{-2}	$.3765 \times 10^{-7}$	$.107 \times 10^{-5}$			
D	$.1834928 \times 10^{1}$	$.2542981 \times 10^{-3}$	$-0.15852458 \times 10^{-5}$	0.3550699×10^{-8}		
F	$.34238440 \times 10^{4}$	$-0.52277204 \times 10^{1}$	$.98557190 \times 10^{-2}$	$-0.11305118 \times 10^{-4}$		
G	$-0.57284294 \times 10^{4}$		$-0.60309325 \times 10^{-2}$	$-0.17462428 \times 10^{-5}$	$0.64112408 \times 10^{-9}$	0.33815137×10^{1}
H	-0.1369402×10^{3}		$.19779974 \times 10^{-1}$	$-0.32285532 \times 10^{-4}$	$.26326563 \times 10^{-7}$	$-0.26896486 \times 10^{1}$
K	$-0.58653696 \times 10^{4}$	$.2224103300 \times 10^{2}$	$.13749042 \times 10^{-1}$	$-0.34031775 \times 10^{-4}$	$.26967687 \times 10^{-7}$	.6918651
L	$-0.57170491 \times 10^{4}$	$.9158658955 \times 10^{1}$	$-0.74950412 \times 10^{-2}$	0.36067657×10^{1}		

where v and v' are the specific volumes of saturated vapor and water, respectively, and dp/dT is the temperature derivative of the vapor pressure of liquid water. The quantity γ is represented with high precision from 273.15 to 423.15 K in units of J/g by the following polynomial equation [3]

$$\gamma = F_0 + F_1 T + F_2 T^2 + F_3 T^3. \tag{44}$$

The coefficients are given in table 2. At $T = 273.15$ K, $\gamma_i = 2500.8384$ J/g. The quantity δ_i, at $T = 273.15$ K, using $v' = 1.00016$ cm^3/g [42] and $dp/dT = 44.4$ Pa/K [3], is 0.0121 J/g. Therefore $l'_i = 2500.8263$ J/g. By appropriate substitutions into eq (38) one obtains $\Delta h_i = 0.2365$ J/g.

2.6. Latent Heat of Sublimation

Substitution of eqs (26) and (41) into (2) gives rise to the following equation for the latent heat of sublimation:

$$\begin{aligned} l = &\left[(\gamma_i - \delta_i + \Delta h_i + l'_i) - (D_0 - A_0)T_i \right. \\ &\left. - \frac{1}{2}(D_1 - A_1)T_i^2 - \frac{1}{3}(D_2 - A_2)T_i^3 - \frac{1}{4}D_3 T_i^4\right] \\ &+ (D_0 - A_0)T + \frac{1}{2}(D_1 - A_1)T^2 + \frac{1}{3}(D_2 - A_2)T^3 \\ &+ \frac{1}{4}D_3 T^4 - \Delta h - \Delta h''. \end{aligned} \tag{45}$$

2.7 Vapor Pressure

Combining eqs (5) and (45), selecting the temperature T_t and vapor pressure p_t at the triple point as the lower limits of integration, taking any temperature T and corresponding vapor pressure p as the upper limits, and performing some simple mathematical manipulations, one obtains

$$\begin{aligned} &\int_{p_t}^{p} d(\ln p) \\ &= \sum_{j=0}^{4} G_j (T^{j-1} - T_t^{j-1}) + G_5 \ln\left(\frac{T}{T_t}\right) \\ &- \int_{T_t}^{T} \frac{\Delta h}{RT^2}\, dT - \int_{T_t}^{T} \frac{\Delta h''}{RT^2}\, dT \\ &- \int_{T_t}^{T} \frac{l}{RT^2}\left(\frac{Z-1}{Z}\right) dT + \int_{T_t}^{T} \frac{l}{ZRT^2}\left(\frac{v''}{v}\right) dT \end{aligned} \tag{46}$$

where $G_0 = -\frac{1}{R}\left[(\gamma_i - \delta_i + \Delta h_i + l''_i) - (D_0 - A_0)T_i - \frac{1}{2}(D_1 - A_1)T_i^2 - \frac{1}{3}(D_2 - A_2)T_i^3 - \frac{1}{4}D_3 T_i^4\right]$ (47)

$$G_2 = \frac{D_1 - A_1}{2R} \tag{48}$$

$$G_3 = \frac{D_2 - A_2}{6R} \tag{49}$$

$$G_4 = \frac{D_3}{12R} \tag{50}$$

and $$G_5 = \frac{D_0 - A_0}{R} \tag{51}$$

The coefficients are given in table 2.

The first two terms on the right-hand side of eq (46) provide the major contribution to the vapor pressure; the integrals are small corrections which account, in part, for the deviation of water vapor from ideal gas behavior. These have been left in integral form because each is a function of p as well as T.

The absolute temperature assigned to the triple point on IPTS-68 is 273.16 K. The corresponding vapor pressure is 611.657 Pa, the definitive value measured by Guildner, Johnson, and Jones [4]. The specific gas constant for water, $R = 0.461520$ J/g K, was derived from the CODATA recommended value of 8.31441 J/mol K for the universal gas constant [43], and 18.015227 g for the molar mass of naturally occurring water vapor on the unified carbon-12 scale.[6]

Because eq (46) is implicit in p it had to be solved by iteration. Each of the integrals on the right-hand side was evaluated at intervals of 0.25 kelvins by means of the trapezoidal rule [47]. Iteration at each interval was terminated when successive values of p differed by less than 0.1 ppm. The magnitudes of the terms in eq (46) are shown in skeleton form in table 3. The magnitudes of the integral terms are equivalent to the relative contributions they make to the vapor pressure. The sum of the integrals increases from zero at the triple point to -0.000389 at -100 °C. Neglecting the integrals, therefore, would introduce an error of up to 389 ppm in the vapor pressure. The sums of the integrals, at intervals of 2 kelvins, were fitted by the method of least squares to the equation

$$\sum \text{integrals} = \sum_{j=0}^{4} H_j\left(T^{j-1} - T_t^{j-1}\right) + H_5 \ln\left(\frac{T}{T_t}\right) \tag{52}$$

with a residual standard deviation [48] of 0.7×10^{-6}. The coefficients are given in table 2. Substituting eq (52) into (46), integrating the left-hand side, and combining terms,

[6] According to Eisenberg and Kauzman [44], who quote Shatenshtein et al. [45], the isotopic content of naturally occurring water depends on its origin. Within the limits of variation normally encountered the isotopes are $H_2{}^{16}O$, $H_2{}^{17}O$, $H_2{}^{18}O$ and HDO and the abundances are 99.73, 0.04, 0.20, and 0.03 percent, respectively. Combining these abundances with the relative atomic masses of the appropriate nuclides, recommended by the Commission on Atomic Weights [46], yielded the value 18.015277 grams for the molecular weight of naturally occurring water.

TABLE 3. *Magnitude of the terms in eq (46)*

t	$\sum_{j=0}^{4} G_j(T^{j-1} - T_t^{j-1}) + G_5 \ln\left(\frac{T}{T_t}\right)$	$\int_{T_t}^{T} \frac{\Delta h}{RT^2}\,dT$	$\int_{T_t}^{T} \frac{\Delta h''}{RT^2}\,dT$	$\int_{T_t}^{T} \frac{1}{RT^2}\left(\frac{Z-1}{Z}\right)dT$	$\int_{T_t}^{T} \frac{1}{ZRT^2}\left(\frac{v''}{v}\right)dT$	$\sum$ integrals	$\ln\left(\frac{p}{p_t}\right)$	p
°C								Pa
0.01	−0.0000000	−0.0000000	0.0000000	0.0000000	−0.0000000	−0.0000000	−0.0000000	611.657
0	−0.0008231	−0.0000000	.0000000	.0000001	−0.0000000	−0.0000001	−0.0008232	611.154
−10	−0.8556016	−0.0000515	.0000001	.0002348	−0.0000031	−0.0001864	−0.8557880	259.923
−20	−1.7784775	−0.0000786	.0000003	.0003614	−0.0000045	−0.0002877	−1.7787652	103.276
−30	−2.7776170	−0.0000920	.0000007	.0004258	−0.0000051	−0.0003397	−2.7779567	38.0239
−40	−3.8625689	−0.0000982	.0000012	.0004565	−0.0000054	−0.0003649	−3.8629338	12.8486
−50	−5.0445714	−0.0001008	.0000018	.0004701	−0.0000055	−0.0003766	−5.0449480	3.94017
−60	−6.3369461	−0.0001018	.0000026	.0004756	−0.0000055	−0.0003818	−6.3373279	1.08204
−70	−7.7556071	−0.0001022	.0000035	.0004776	−0.0000055	−0.0003844	−7.7559915	0.261893
−80	−9.3197265	−0.0001023	.0000045	.0004783	−0.0000055	−0.0003860	−9.3201125	.0548068
−90	−11.0526186	−0.0001024	.0000058	.0004784	−0.0000055	−0.0003874	−11.0530060	.00968832
−100	−12.9829316	−0.0001024	.0000074	.0004785	−0.0000055	−0.0003890	−12.9833206	.00140580

$$\sum \text{integrals} = -\int_{T_t}^{T} \frac{\Delta h}{RT^2}\,dT - \int_{T_t}^{T} \frac{\Delta h''}{RT^2}\,dT - \int_{T_t}^{T} \frac{1}{RT^2}\left(\frac{Z-1}{Z}\right)dT + \int_{T_t}^{T} \frac{1}{ZRT^2}\left(\frac{v''}{v}\right)dT$$

one finally obtains

$$\ln\left(\frac{p}{p_t}\right) = \sum_{j=0}^{4} K_j(T^{j-1} - T_t^{j-1}) + K_5 \ln\left(\frac{T}{T_t}\right) \tag{53}$$

which reduces to

$$\ln p = \sum_{j=0}^{4} K_j T^{j-1} + K_5 \ln T \tag{54}$$

where $K_0 = G_0 + H_0$ (55)

$$K_1 = -\left(\frac{K_0}{T_t} + K_2 T_t + K_3 T_t^2 + K_4 T_t^3 + K_5 \ln T_t - \ln p_t\right) \tag{56}$$

$$K_2 = G_2 + H_2 \tag{57}$$

$$K_3 = G_3 + H_3 \tag{58}$$

$$K_4 = G_4 + H_4 \tag{59}$$

$$K_5 = G_5 + H_5. \tag{60}$$

The coefficients are given in table 2.

The feasibility of reducing the number of terms in eqs (53) and (54) was investigated. Values of vapor pressure were generated from eq (53) at one-kelvin intervals from the ice point to 172.15 K and fitted by the method of least squares to equations of the form

$$\ln\left(\frac{p}{p_t}\right) = \sum_{j=0}^{n} L_j(T^{j-1} - T_t^{j-1}) + L_{n+1} \ln\left(\frac{T}{T_t}\right) \tag{61}$$

for $0 \leqq n \leqq 4$ with and without the $\ln\left(\frac{T}{T_t}\right)$ term. For $n = 2$, with the $\ln\left(\frac{T}{T_t}\right)$ term included, the standard deviation of the fit was 14 ppm and the maximum deviation was 26 ppm. Thus, for $n = 2$, eq (61) becomes

$$\ln\left(\frac{p}{p_t}\right) = \sum_{j=0}^{2} L_j(T^{j-1} - T_t^{j-1}) + L_3 \ln\left(\frac{T}{T_t}\right) \tag{62}$$

or, alternately,

$$\ln p = \sum_{j=0}^{2} L_j T^{j-1} + L_3 \ln T \tag{63}$$

where

$$L_1 = -\frac{L_0}{T_t} - L_2 T_t - L_3 \ln T_t + \ln p_t \tag{64}$$

The coefficients are given in table 2.

3. Error Analysis

It is of interest to assign reasonable bounds of uncertainty to the independent variables and constants and then calculate the effect of these uncertainties on p. Start with eq (5) and recall that

$$Z = 1 + B'p \tag{65}$$

$$v = \frac{ZRT}{p} \tag{66}$$

$$v'' = v''_{P_a,T_i}\left[1 + 3\int_{T_i}^{T} \alpha_{P_a}\, dT\right]\left[1 - k(p - P_a)\right] \tag{67}$$

$$l = \int_{T_i}^{T} c_{p_0}\, dT + \gamma_i - \delta_i + \Delta h_i - \Delta h - \int_{T_i}^{T} c''_{P_a}\, dT - \Delta h'' + l''_i \tag{68}$$

where

$$\Delta h = RT^2 \frac{\partial B'}{\partial T} p \tag{69}$$

and

$$\Delta h'' = \int_{p_i}^{P_a}\left[v'' - T\left(\frac{\partial v''}{\partial T}\right)_{p_i}\right]_{T_i} dP + \int_{P_a}^{p}\left[v'' - T\left(\frac{\partial v''}{\partial T}\right)_{P_a}\right]_{T} dP \tag{70}$$

Substituting the above equations into eq (5) converts the latter into a functional relationship of independent variables and constants. The vapor pressure is calculated by iteration and numerical integration, as previously described. The calculation then is repeated with each variable and constant separately augmented by its appropriate estimated error.

The absolute temperature T enters into eq (5) as the independent variable so that it is subject neither to experimental nor scale error. However, experimental and scale errors in the temperature affect the uncertainties in the independent variables; therefore, these temperature errors are contained in the estimated errors of the independent variables. Since T_t is assigned values on IPTS-68, it will be assumed that its estimated uncertainty is zero.

The estimated error in the specific gas constant for water vapor R arises from the assigned (three standard deviations) uncertainty [43] in the molar gas constant of 78×10^{-5} J/mol K and from a calculated (three standard deviations) uncertainty in the molecular weight of naturally occurring water of 9×10^{-5} g/mol based on the assigned uncertainties [46] in the relative atomic masses of the pertinent nuclides. The resultant estimated error (three standard deviations) in R is 45×10^{-6} J/g K (94 ppm).

There are no experimental data below 273.15 K on which to base an estimate of the uncertainty in the virial coefficient B′ nor in the derivative dB'/dT. Therefore, four sets of extrapolated virial coefficients were calculated, using the empirical equations of Goff and Gratch [12–14], Keyes [15, 16], and Juza as given by Bain [17], and then differences were obtained from the latest Keyes values [16]. The estimated uncertainty was set at thrice the maximum difference. This uncertainty in B' contributed to a corresponding uncertainty in dB'/dT.

P_a is standard atmospheric pressure. Because this is an assigned value it will be assumed that its uncertainty is zero.

Guildner, Johnson, and Jones [4] have assigned an estimated uncertainty (three standard deviations plus systematic errors) of 0.010 Pa (16 ppm) to their measured value of the vapor pressure at the triple point p_t. Their estimated uncertainty will be used here.

According to Ginnings and Corruccini [19], the combined random and systematic uncertainty in their determination of the density of ice at 0 °C and 1 atmosphere is 0.00005 g/ml. This value was converted to 0.00006 cm³/g and the latter used as the estimated uncertainty in the specific volume of ice v''_{P_a,T_i}. The estimated uncertainty in the coefficient α_{P_a} will be taken as three times the standard deviation of the fit [48] as given by eq (10), that is, 0.50×10^{-5} cm/cm K. Leadbetter [27] has ascribed an uncertainty of 5 percent to his values of the adiabatic compressibility of ice, namely 0.6 cm³/cm³ Pa. The same uncertainty is therefore used for the isothermal compressibility k, since the latter is derived from Leadbetter's values.

Friedman and Haar [37] have computed c_{p_0}/R to six significant figures. However, they did not give an estimate of the uncertainty in their calculated values. An error of 100 ppm therefore was assigned to c_{p_0}/R. Combining this error along with 99 ppm for the estimated uncertainty in R and 9 ppm which represents three times the residual standard deviation of the fit of eq (33) resulted in an estimated error of 140 ppm in c_{p_0}, i.e., 0.26×10^{-3} J/g K.

In the absence of any other criteria for estimating the uncertainty in c''_{P_a}, a value of 0.0103 J/g K was selected which equals three times the standard deviation of the fit of eq (19), 0.0099 J/g K, plus an estimated error of 0.0004 J/g K due to ambiguities in the temperature scale employed by Giauque and Stout.

The estimated error in γ_i was taken as 0.45 J/g which is three times the standard deviation of the fit of eq (44). The uncertainty in δ_i was conservatively estimated at less than one percent, that is, less than 0.0001 J/g. Osborne [36] has estimated that the random and systematic error in l''_i was 0.2 J/g and his value, therefore, was used here.

The quantity $\Delta h''$ varies from zero at 0 °C to about −0.002 J/g at −100 °C. Since it is small compared to l (~ 2830 J/g), its functional dependence on other parameters will be ignored. The uncertainty in $\Delta h''$ was estimated at less than 0.0001 J/g.

A summary of the individual estimated errors contributing to the total error in the predicted vapor pressure is given in table 4. The corresponding uncertainty in p due to each of the enumerated errors is shown in table 5. The square root of the sum of the squares of the individual errors was used as the best estimate of the overall maximum error in p [49]. As the temperature decreases from the triple point to −100 °C, the estimated relative error in p increases from 16 ppm to 0.5 percent.

TABLE 4. *Summary of estimated errors in variables and constants*

Temperature	Parameter											
t	R		B'		P_t		v''_{P_a,T_t}		k		c_{p_a}	
°C	Magnitude J/gK	Error J/gK	Magnitude 1/Pa	Error 1/Pa	Magnitude Pa	Error Pa	Magnitude cm^3/g	Error cm^3/g	Magnitude cm^3/cm^3 Pa	Error cm^3/cm^3Pa	Magnitude J/gK	Error J/gK
0.01	0.461520	0.000045	-0.6151×10^{-6}	0.6303×10^{-6}	611.657	0.010	1.09089	0.00006	0.13×10^{-9}	0.6×10^{-11}	1.85848	0.00026
0	.461520	.000045	-0.6151×10^{-6}	$.6303 \times 10^{-6}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85848	.00026
−10	.461520	.000045	-0.7420×10^{-6}	$.9333 \times 10^{-6}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85677	.00026
−20	.461520	.000045	-0.9036×10^{-6}	$.1432 \times 10^{-5}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85532	.00026
−30	.461520	.000045	-0.1112×10^{-5}	$.2278 \times 10^{-5}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85408	.00026
−40	.461520	.000045	-0.1383×10^{-5}	$.3755 \times 10^{-5}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85305	.00026
−50	.461520	.000045	-0.1741×10^{-5}	$.6414 \times 10^{-5}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85219	.00026
−60	.461520	.000045	-0.2219×10^{-5}	$.1135 \times 10^{-4}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85149	.00026
−70	.461520	.000045	-0.2866×10^{-5}	$.2083 \times 10^{-4}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85093	.00026
−80	.461520	.000045	-0.3753×10^{-5}	$.3961 \times 10^{-4}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85049	.00026
−90	.461520	.000045	-0.4987×10^{-5}	$.7806 \times 10^{-4}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.85014	.00026
−100	.461520	.000045	-0.6728×10^{-5}	$.1594 \times 10^{-3}$	611.657	.010	1.09089	.00006	$.13 \times 10^{-9}$	$.6 \times 10^{-11}$	1.84987	.00026

TABLE 4. *Summary of estimated errors in variables and constants*—continued

Temperature	Parameter											
t	c''_{P_a}		γ_t		δ_t		l''_t		$\Delta h''$		α_{P_a}	
°C	Magnitude J/gK	Error J/gK	Magnitude J/g	Error J/g	Magnitude J/g	Error J/g	Magnitude J/g	Error J/g	Magnitude J/g	Error J/g	Magnitude cm/cm K	Error cm/cm K
0.01	2.1069	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0000	0.0001	0.544×10^{-4}	0.50×10^{-5}
0	2.1068	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0000	0.0001	0.544×10^{-4}	0.50×10^{-5}
−10	2.0312	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0006	0.0001	0.521×10^{-4}	0.50×10^{-5}
−20	1.9562	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0009	0.0001	0.499×10^{-4}	0.50×10^{-5}
−30	1.8818	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0012	0.0001	0.476×10^{-4}	0.50×10^{-5}
−40	1.8082	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0014	0.0001	0.453×10^{-4}	0.50×10^{-5}
−50	1.7351	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0016	0.0001	0.430×10^{-4}	0.50×10^{-5}
−60	1.6627	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0017	0.0001	0.408×10^{-4}	0.50×10^{-5}
−70	1.5910	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0019	0.0001	0.385×10^{-4}	0.50×10^{-5}
−80	1.5199	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0020	0.0001	0.362×10^{-4}	0.50×10^{-5}
−90	1.4494	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0022	0.0001	0.340×10^{-4}	0.50×10^{-5}
−100	1.3797	0.0103	2800.84	0.45	0.0121	0.0001	333.43	0.2	−0.0023	0.0001	0.317×10^{-4}	0.50×10^{-5}

TABLE 5. *Summary of equivalent errors in vapor pressure due to estimated errors in variables and constants*

Temperature	Parameter											Estimated Overall Error[a]
t	R	B'	p_t	v''_{P_a,T_i}	k	c_{p_o}	c''_{P_a}	γ_i	δ_i	l''_i	$\Delta h''$	α_{P_a}	
°C	Estimated error in vapor pressure due to estimated error in indicated parameter, ppm												ppm
0.01	0	0	16	<1	<1	0	0	0	<1	0	<1	<1	16
0	0	0	16	<1	<1	0	0	0	<1	0	<1	<1	16
−10	83	532	16	<1	<1	0	15	135	<1	60	<1	<1	559
−20	173	950	16	<1	<1	1	66	282	<1	125	<1	<1	1016
−30	270	1289	16	<1	<1	3	157	440	<1	195	<1	<1	1411
−40	376	1580	16	<1	<1	7	295	612	<1	272	<1	<1	1781
−50	491	1845	16	<1	<1	12	488	799	<1	355	<1	<1	2156
−60	618	2101	16	<1	<1	18	746	1004	<1	436	<1	<1	2561
−70	756	2363	16	<1	<1	27	1081	1229	<1	546	<1	<1	3022
−80	909	2641	16	<1	<1	38	1508	1477	<1	656	<1	<1	3562
−90	1078	2943	16	<1	<1	52	2043	1752	<1	778	<1	<1	4064
−100	1278	3279	16	<1	<1	72	2708	2055	<1	912	<1	<1	4978

[a] Square root of the sum of the squares of the estimated errors contributed by each parameter.

4. Comparisons

The first experimental values of the vapor pressure of ice were reported by Regnault [50] in 1847. Subsequently, measurements were made by Fischer [51], Juhlin [52], and Marvin [53]. In 1909, Scheel and Heuse [54] at the Physikalisch-Technische Reichsanstalt (PTR) published the results of their work which superseded all earlier determinations for range, precision and accuracy. Using a Rayleigh inclined manometer and a platinum resistance thermometer they measured the vapor pressure from 0 to −67 °C. In a second paper [55] they suggested that temperatures interpolated from the Callendar formula would be more in accord with the thermodynamic scale than the temperatures given in their first paper. In 1919, the PTR issued revised values of the Scheel and Heuse measurements [56]. Although not explicitly stated, these new values appear to have been based on the use of the Callendar formula for interpolating temperature measurements with platinum resistance thermometers.

Weber [57] in 1915, employing both a hot-wire manometer and a Knudsen radiometer, made measurements from −22 to −98 °C. A limited number of determinations were made by Nernst [58] in 1909 and by Drucker, Jimeno, and Kangro [59] in 1915. Douslin and McCullough [60] in 1963, using an inclined dead-weight piston gage, made measurements to −30 °C. Jancso, Pupezin, and Van Hook [61] in 1970 used a differential capacitance manometer to effect a series of determinations to −78 °C. They used the vapor pressure of ice at 0 °C as the reference pressure for their manometer, assigning to it the value 4.581 mm Hg (610.7 Pa).

A comparison of eq (54) with these measurements, excluding the early work of Regnault, Fischer, Juhlin, and Marvin, is shown in figure 1. The temperatures given by the investigators were converted to IPTS-68 for this comparison. Many of the errors associated with these measurements are not given explicitly so it is difficult to determine both their sources and magnitudes. Therefore, no attempt has been made to assign uncertainties nor to make corrections except for the temperature scale and, where noted, for reference pressure. Because the Jancso, Pupezin and Van Hook pressure measurements were made with respect to the vapor pressure at the ice point they were adjusted to conform to the vapor pressure at 0 °C predicted by eq (54), namely, 611.154 Pa rather than 610.7 Pa (4.581 mm Hg) which Jancso, Pupezin, and Van Hook used.

The sets of data of some of the investigators tend to deviate from eq (54) in consistent ways. The Scheel and Heuse measurements (black dots) are generally lower in magnitude (except for two points) than the vapor pressures calculated from eq (54); the differences increase until at −67 °C they are of the order of 70 percent. Weber's measurements (pluses) are much closer, but they also are lower in magnitude (except for two points); at about −98 °C, where suprisingly Weber obtained several measurements, the deviations are as large as 25 percent. Among all the investigators, the best agreement is achieved with Weber. However, Weber made no measurements above −22 °C.

Of the three measurements of Nernst (black squares) two (at −30 and −50 °C) show positive differences and the third (at −40 °C) a negative difference, none exceeding 2 percent. The Drucker, Jimeno, and Kangro measurements (black triangles) tend to be high, with one value (at −34 °C) differing by as much as +12.3 percent. The differences for the Douslin and McCullough measurements (asterisks), which cover the range of temperature from −2 to −31.4 °C, are almost equally positive and negative in number and reach a magnitude of about one percent at −31.4 °C. The Jancso, Pupezin, and Van Hook differences (circles) scatter more or less randomly in the temperature region above −15 °C; from −35 °C and below, the differences are all positive, reaching a magnitude of 20 percent at about −78 °C.

The differences far exceed the estimated uncertainty of the values predicted by eq (54). It may be inferred from the difference patterns displayed by these several sets of data that there are significant systematic errors present in each of these data. The obvious conclusion is that a definitive set of measurements remains to be made.

Numerous empirical equations have been proposed to represent the vapor pressure of ice. Scheel and Heuse [54] and Thiesen [62] derived formulas which fit the original Scheel and Heuse data [54]. The equations of Tetens [63] and Erdelyszky as given by Sonntag [64], are of the Magnus type [65] with different sets of coefficients. The Jancso, Pupezin, and Van Hook [61] empirical equation is based on a least square fit to their own measurements.

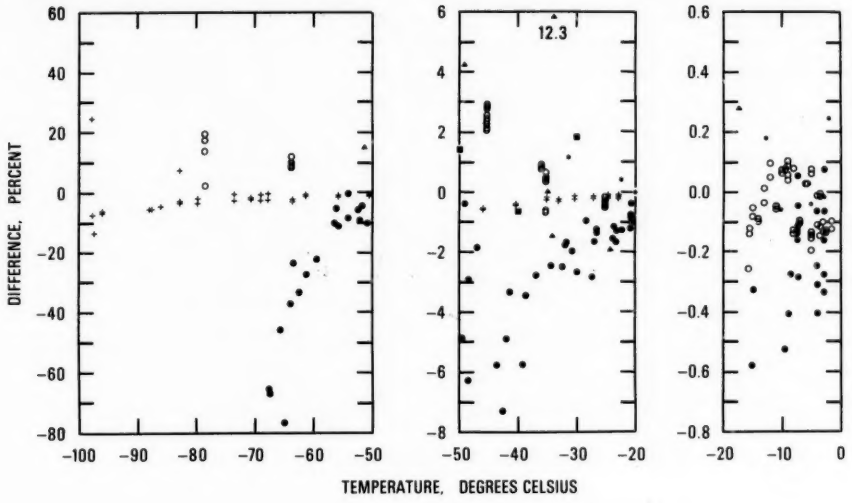

FIGURE 1. *Comparision with vapor pressure measurements.*

Relative vapor pressure difference $\left[\frac{\text{measurement} - \text{eq (54)}}{\text{eq (54)}} \times 100\right]$ between measurement and eq (54) in percent: ● Scheel and Heuse; + Weber; ■ Nernst; ▲ Drucker, Jimeno and Kangro; * Douslin and McCullough; ○ Jancso, Pupezin and Van Hook.

There also have been repeated attempts to derive thermodynamically based expressions for the vapor pressure of ice. The equations of Nernst [58], Washburn [66], Whipple [67], and Goff and Gratch [68, 69] were obtained by integrating the Clausius-Clapeyron equation and inserting selected values of thermal data. Vapor pressures based on the Nernst equation were included in an early edition of the Smithsonian Meteorological Tables [70]. Vapor pressures based on the Washburn equation are given in several standard references [71, 72] often used by chemists. The Goff formulation is used in the meteorological and air conditioning disciplines [73–75]. The equation ascribed to Kelley [76] is based on an expression he derived for the free energy difference which, when integrated with respect to temperature, yields the logarithm of the vapor pressure. This equation is given in a widely used set of German tables [77] and by Dushman [78]. The equations of Miller [79] and Jancso, Pupezin, and Van Hook [61] were derived from an expression for the vaporization process given in terms of vapor fugacity and condensed phase activity [80]. The Miller equation was not presented in explicit form although calculated vapor pressures were given in an abbreviated table.

A comparison between the empirical equations and eq (54) is shown in figure 2 and a similar comparison between the thermodynamic equations and eq (54) is shown in figure 3. Because the Thiesen and the Whipple equations give functional relationships for the ratio p/p_0, where p is the vapor pressure at any given temperature and p_0 is the vapor pressure at 0 °C, the value predicted by eq (54) was inserted for p_0 to compute p rather than the value used by these investigators. No attempt was made to adjust or correct any of the empirical equations from the temperature scale used by the investigator in his formulation to IPTS-68.

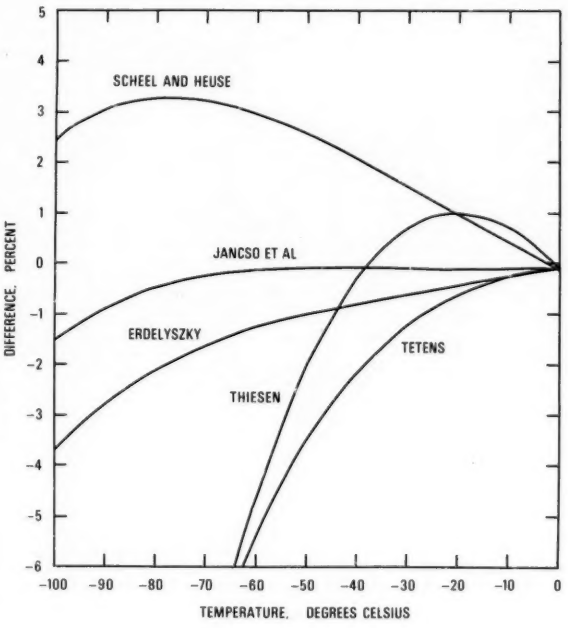

FIGURE 2. *Comparison with empirical equations.*

Relative vapor pressure difference $\left[\frac{\text{other} - \text{eq (54)}}{\text{eq (54)}} \times 100\right]$ between empirical equation cited in the literature and eq (54) in percent.

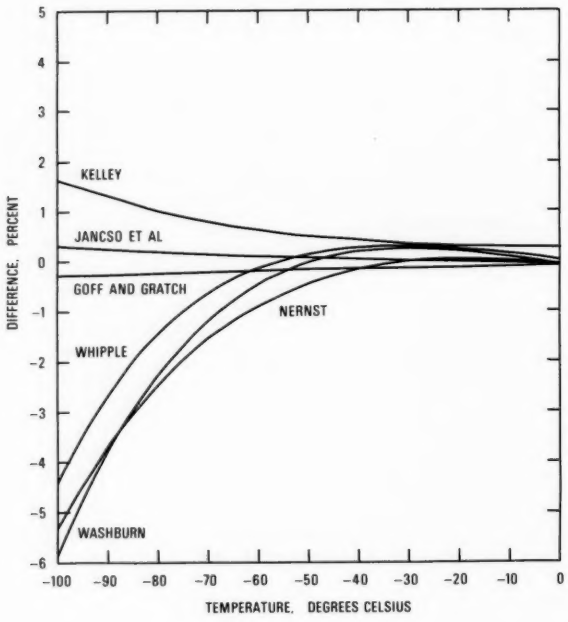

FIGURE 3. *Comparison with thermodynamic equations.*
Relative vapor pressure difference $\left[\frac{\text{other} - \text{eq (54)}}{\text{eq (54)}} \times 100\right]$ between thermodynamic equation cited in the literature and eq (54) in percent.

All the empirical formulations, except that of Jancso, Pupezin, and Van Hook, deviate substantially from eq (54). This, in part, may be accounted for by errors in the temperature scale. More important, however, is the fact that these equations were fitted to experimental data and it has already been demonstrated (see fig. 1) that there are significant differences between those data and eq (54). On the other hand, the Jancso, Pupezin, and Van Hook data differ randomly from eq (54) above −15 °C. Therefore, it is reasonable to expect their empirical equation to agree closely with eq (54) in this region, as indeed it does. What is not clear is why at lower temperatures, say from −50 to −80 °C, the differences between their equation and eq (54) are negative whereas the differences between their measurements and eq (54) are positive. No significance is attached to the differences below −80 °C because their equation was not fitted to data at these lower temperatures and hence is an extrapolation.

There is much better accord between the thermodynamic equations and eq (54), at least down to about −40 °C. Below −40 °C the Kelley, Whipple, Nernst, and Washburn equations deviate increasingly from eq (54); at −100 °C, they differ from eq (54) by +1.6, −4.4, −5.4, and −5.8 percent, respectively. There is good agreement between the Goff and Gratch equation and eq (54); the former yields calculated values that are smaller by 0.08 percent at 0 °C and by 0.29 percent at −100 °C. There is also good agreement between the Jancso, Pupezin, and Van Hook equation and eq (54); the vapor pressures from their thermodynamic calculations are smaller by 0.06 percent at 0 °C but are larger by 0.31 percent at −100 °C. The vapor pressures from the Goff and Gratch equation and the Jancso, Pupezin and Van Hook equation straddle both sides of those derived from eq (54).

5. Tabulations

Vapor pressures were computed from eq (54) and are given in pascals as a function of temperature (in degrees Celsius on the IPTS-68 scale) at 0.1-degree intervals from 0 to −100 °C. These computed values, as well as the derivative with respect to temperature at intervals of 1 degree C, are given in table 6.

6. Discussion

Two equations are offered for use by those who wish to compute the vapor pressure rather than to select or interpolate it from tabulated values. Equation (54) is the preferred equation because it has a rational thermodynamic basis. If a simpler form is desired, then eq (63) may be used, but it should be remembered that the latter equation is empirical. Although the vapor pressures in table 6 are given to six significant figures, the accuracy ascribed to these values is no better than that listed in table 5. Finally, because of the truncating procedure used in the calculation, the last significant figure may differ by 1 from the best rounded value.

TABLE 6. *Saturation vapor pressure over ice*

Deg	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Derivative
C	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa/K
−0	611.153	606.140	601.164	596.225	591.323	586.458	581.630	576.837	572.081	567.360	48.7738
−1	562.675	558.025	553.411	548.830	544.285	539.774	535.297	530.853	526.444	522.067	45.2441
−2	517.724	513.414	509.136	504.891	500.679	496.498	492.349	488.232	484.146	480.091	41.9451
−3	476.068	472.075	468.112	464.180	460.278	456.406	452.564	448.751	444.968	441.213	38.8634
−4	437.488	433.791	430.123	426.483	422.871	419.287	415.731	412.202	408.700	405.226	35.9864
−5	401.779	398.358	394.964	391.597	388.256	384.940	381.651	378.387	375.149	371.936	33.3021
−6	368.748	365.585	362.446	359.333	356.244	353.179	350.138	347.121	344.128	341.158	30.7990
−7	338.212	335.289	332.389	329.512	326.658	323.826	321.017	318.230	315.465	312.722	28.4662
−8	310.001	307.302	304.624	301.967	299.332	296.717	294.124	291.551	288.998	286.467	26.2936
−9	283.955	281.464	278.992	276.540	274.108	271.696	269.303	266.929	264.575	262.239	24.2713
−10	259.922	257.624	255.345	253.084	250.841	248.617	246.410	244.222	242.051	239.898	22.3900
−11	237.762	235.644	233.543	231.459	229.393	227.343	225.310	223.293	221.293	219.309	20.6412
−12	217.342	215.391	213.456	211.537	209.633	207.745	205.873	204.017	202.175	200.349	19.0163
−13	198.538	196.742	194.961	193.194	191.442	189.705	187.982	186.274	184.579	182.899	17.5077
−14	181.233	179.581	177.942	176.318	174.706	173.109	171.524	169.953	168.396	166.851	16.1079
−15	165.319	163.800	162.294	160.801	159.320	157.852	156.396	154.952	153.521	152.101	14.8099
−16	150.694	149.299	147.915	146.544	145.184	143.835	142.498	141.173	139.858	138.555	13.6070
−17	137.263	135.982	134.713	133.453	132.205	130.968	129.741	128.524	127.318	126.123	12.4932
−18	124.938	123.763	122.598	121.443	120.298	119.163	118.038	116.923	115.817	114.721	11.4624
−19	113.634	112.557	111.489	110.431	109.381	108.341	107.310	106.288	105.275	104.271	10.5091
−20	103.276	102.289	101.311	100.341	99.3809	98.4284	97.4843	96.5485	95.6210	94.7016	9.62823
−21	93.7904	92.8872	91.9920	91.1047	90.2253	89.3537	88.4898	87.6336	86.7850	85.9439	8.81467
−22	85.1104	84.2842	83.4655	82.6540	81.8498	81.0528	80.2629	79.4801	78.7043	77.9355	8.06388
−23	77.1735	76.4184	75.6701	74.9286	74.1937	73.4655	72.7438	72.0286	71.3199	70.6176	7.37151
−24	69.9217	69.2321	68.5487	67.8716	67.2005	66.5356	65.8768	65.2239	64.5770	63.9360	6.73347
−25	63.3008	62.6715	62.0479	61.4300	60.8178	60.2112	59.6101	59.0146	58.4245	57.8399	6.14595
−26	57.2607	56.6868	56.1182	55.5548	54.9966	54.4436	53.8958	53.3530	52.8152	52.2824	5.60533
−27	51.7546	51.2317	50.7136	50.2003	49.6919	49.1882	48.6892	48.1948	47.7051	47.2199	5.10825
−28	46.7393	46.2632	45.7916	45.3244	44.8616	44.4031	43.9489	43.4991	43.0534	42.6120	4.65155
−29	42.1748	41.7417	41.3126	40.8877	40.4667	40.0498	39.6368	39.2278	38.8226	38.4213	4.23227
−30	38.0238	37.6301	37.2402	36.8540	36.4714	36.0926	35.7173	35.3457	34.9776	34.6131	3.84764
−31	34.2521	33.8945	33.5404	33.1897	32.8423	32.4983	32.1577	31.8203	31.4862	31.1554	3.49509
−32	30.8277	30.5032	30.1819	29.8637	29.5486	29.2365	28.9275	28.6215	28.3185	28.0185	3.17218
−33	27.7214	27.4272	27.1358	26.8474	26.5617	26.2789	25.9988	25.7215	25.4469	25.1751	2.87668
−34	24.9059	24.6394	24.3755	24.1142	23.8555	23.5993	23.3457	23.0947	22.8461	22.5999	2.60647
−35	22.3563	22.1150	21.8762	21.6397	21.4056	21.1739	20.9444	20.7173	20.4924	20.2698	2.35960
−36	20.0494	19.8312	19.6152	19.4014	19.1898	18.9803	18.7729	18.5675	18.3643	18.1631	2.13424
−37	17.9640	17.7669	17.5717	17.3786	17.1874	16.9982	16.8108	16.6254	16.4419	16.2603	1.92868
−38	16.0805	15.9025	15.7264	15.5521	15.3795	15.2088	15.0397	14.8725	14.7069	14.5430	1.74136
−39	14.3809	14.2204	14.0615	13.9043	13.7488	13.5948	13.4424	13.2916	13.1424	12.9947	1.57080
−40	12.8486	12.7040	12.5609	12.4192	12.2791	12.1404	12.0032	11.8674	11.7330	11.6000	1.41564
−41	11.4685	11.3383	11.2095	11.0820	10.9559	10.8311	10.7076	10.5854	10.4645	10.3449	1.27461
−42	10.2266	10.1095	9.99366	9.87903	9.76563	9.65343	9.54243	9.43260	9.32395	9.21646	1.14655
−43	9.11011	9.00490	8.90082	8.79785	8.69598	8.59521	8.49552	8.39690	8.29934	8.20283	1.03036
−44	8.10736	8.01292	7.91950	7.82708	7.73567	7.64525	7.55580	7.46733	7.37981	7.29325	0.925056
−45	7.20763	7.12294	7.03917	6.95631	6.87436	6.79330	6.71313	6.63384	6.55542	6.47785	.829693
−46	6.40114	6.32526	6.25022	6.17601	6.10262	6.03003	5.95824	5.88725	5.81704	5.74761	.743420
−47	5.67894	5.61104	5.54389	5.47749	5.41182	5.34688	5.28267	5.21917	5.15638	5.09429	.665446
−48	5.03290	4.97219	4.91216	4.85280	4.79411	4.73608	4.67870	4.62196	4.56587	4.51040	.595041
−49	4.45556	4.40134	4.34773	4.29473	4.24233	4.19052	4.13930	4.08866	4.03860	3.98910	.531534
−50	3.94017	3.89179	3.84397	3.79669	3.74996	3.70375	3.65808	3.61293	3.56829	3.52417	.474306
−51	3.48056	3.43744	3.39483	3.35270	3.31106	3.26990	3.22921	3.18900	3.14925	3.10996	.422790
−52	3.07113	3.03275	2.99481	2.95731	2.92025	2.88362	2.84742	2.81165	2.77628	2.74134	.376464

TABLE 6. *Saturation vapor pressure over ice*—continued

Deg	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Derivative
	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa/K
C	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa	MPa/K
−53	2.70680	2.67266		2.60559	2.57265	2.54009	2.50791	2.47611	2.44469	2.41364	.334847
−54	2.38296	2.35263		2.29306	2.26381	2.23490	2.20633	2.17810	2.15021	2.12265	.297501
−55	2.09542	2.06852		2.01567	1.98972	1.96408	1.93874	1.91371	1.88898	1.86455	.264024
−56	1.84042	1.81657		1.76974	1.74674	1.72403	1.70159	1.67942	1.65752	1.63589	.234047
−57	1.61452	1.59340		1.55195	1.53160	1.51150	1.49165	1.47204	1.45266	1.43353	.207235
−58	1.41463	1.39596		1.35931	1.34133	1.32356	1.30602	1.28869	1.27157	1.25467	.183280
−59	1.23797	1.22149		1.18912	1.17324	1.15756	1.14207	1.12678	1.11167	1.09676	.161902
−60	1.08203	1.06749		1.03894	1.02494	1.01111	.997462	.983980	.970668	.957524	.142846
−61	944.545	931.731	919.079	906.587	894.253	382.076	870.053	858.183	846.465	834.895	125.879
−62	823.473	812.196	801.064	790.074	779.225	768.514	757.941	747.504	737.201	727.030	110.790
−63	716.990	707.079	697.297	687.640	678.109	668.700	659.414	650.248	641.200	632.270	97.3887
−64	623.457	614.758	606.172	597.698	589.335	581.081	572.935	564.895	556.961	549.131	85.4990
−65	541.403	533.778	526.252	518.826	511.497	504.265	497.128	490.086	483.137	476.280	74.9642
−66	469.514	462.838	456.250	449.750	443.337	437.009	430.765	424.605	418.527	412.530	65.6416
−67	406.613	400.776	395.017	389.335	383.730	378.200	372.745	367.363	362.054	356.817	57.4022
−68	351.650	346.553	341.525	336.566	331.674	326.848	322.088	317.393	312.761	308.193	50.1295
−69	303.688	299.244	294.860	290.537	286.273	282.068	277.920	273.829	269.795	265.816	43.7185
−70	261.892	258.023	254.206	250.443	246.732	243.072	239.463	235.904	232.394	228.934	38.0746
−71	225.521	222.157	218.389	215.567	212.342	209.161	206.025	202.933	199.885	196.879	33.1128
−72	193.916	190.994	188.114	185.274	182.475	179.715	176.994	174.311	171.667	169.060	28.7565
−73	166.491	163.958	161.461	158.999	156.573	154.182	151.824	149.501	147.210	144.953	24.9372
−74	142.728	140.535	138.373	136.243	134.143	132.074	130.035	128.025	126.044	124.092	21.5935
−75	122.168	120.273	118.404	116.563	114.749	112.961	111.200	109.464	107.753	106.068	18.6702
−76	104.407	102.771	101.159	99.5705	98.0053	96.4631	94.9437	93.4468	91.9720	90.5190	16.1183
−77	89.0875	87.6772	86.2879	84.9192	83.5709	82.2427	80.9342	79.6453	78.3757	77.1250	13.8938
−78	75.8930	74.6795	73.4842	72.3069	71.1472	70.0050	68.8800	67.7720	66.6807	65.6059	11.9577
−79	64.5473	63.5047	62.4780	61.4668	60.4710	59.4904	58.5246	57.5736	56.6371	55.7149	10.2751
−80	54.8067	53.9125	53.0320	52.1649	51.3112	50.4706	49.6429	48.8280	48.0256	47.2356	8.81511
−81	46.4578	45.6921	44.9381	44.1959	43.4652	42.7458	42.0376	41.3405	40.6541	39.9785	7.55021
−82	39.3135	38.6588	38.0144	37.3800	36.7556	36.1410	35.5361	34.9407	34.3546	33.7778	6.45610
−83	33.2101	32.6514	32.1014	31.5602	31.0276	30.5034	29.9875	29.4799	28.9803	28.4886	5.51125
−84	28.0049	27.5288	27.0603	26.5994	26.1458	25.6995	25.2603	24.8282	24.4031	23.9848	4.69665
−85	23.5732	23.1683	22.7699	22.3780	21.9924	21.6131	21.2399	20.8728	20.5116	20.1563	3.99550
−86	19.8068	19.4630	19.1249	18.7922	18.4650	18.1432	17.8266	17.5152	17.2090	16.9077	3.39303
−87	16.6115	16.3201	16.0336	15.7517	15.4746	15.2020	14.9339	14.6703	14.4111	14.1562	2.87625
−88	13.9055	13.6590	13.4166	13.1783	12.9440	12.7135	12.4870	12.2642	12.0452	11.8299	2.43374
−89	11.6182	11.4100	11.2054	11.0042	10.8065	10.6120	10.4209	10.2330	10.0483	9.86680	2.05550
−90	9.68833	9.51290	9.34047	9.17098	9.00439	8.84064	8.67971	8.52153	8.36607	8.21329	1.73278
−91	8.06313	7.91556	7.77053	7.62801	7.48795	7.35031	7.21506	7.08216	6.95156	6.82323	1.45794
−92	6.69714	6.57324	6.45150	6.33189	6.21437	6.09890	5.98546	5.87401	5.76451	5.65694	1.22432
−93	5.55126	5.44745	5.34546	5.24528	5.14686	5.05019	4.95523	4.86195	4.77033	4.68034	1.02610
−94	4.59195	4.50513	4.41986	4.33612	4.25387	4.17310	4.09377	4.01586	3.93935	3.86422	0.858252
−95	3.79044	3.71799	3.64685	3.57699	3.50839	3.44103	3.37490	3.30997	3.24621	3.18361	.716394
−96	3.12216	3.06182	3.00258	2.94443	2.88734	2.83129	2.77627	2.72226	2.66924	2.61720	.596744
−97	2.56612	2.51597	2.46676	2.41845	2.37103	2.32450	2.27882	2.23400	2.19000	2.14683	.496029
−98	2.10445	2.06287	2.02207	1.98202	1.94273	1.90417	1.86634	1.82921	1.79279	1.75704	.411429
−99	1.72198	1.68757	1.65381	1.62069	1.58820	1.55632	1.52505	1.49437	1.46428	1.43476	.340513
−100	1.40580										

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Standard pH Values for the Potassium Hydrogen Phthalate Reference Buffer Solution from 0 to 60 °C

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The standard pH values of the solution of potassium hydrogen phthalate (molality 0.05 mol kg^{-1}) have been redetermined over the temperature range 0 to 60 °C, using SRM 185d. Extensive measurements were made of the emf of cells of the type

$$Pd;H_2(g,\ 1\ atm)|KH\ phthalate\ (m = 0.05),\ KCl\ (m)|AgCl;Ag$$

where m_{KCl} was 0.015, 0.01, or 0.005 mol kg^{-1}, from which values of the acidity function $p(a_H\gamma_{Cl})$ were derived. The pH convention defines γ_{Cl} in the range of ionic strengths 0 to 0.1 mol kg^{-1} and permits conventional values of pa_H to be obtained. According to NBS procedures, pa_H for selected reference solutions is identified with the standard pH(S) in the operational definition of pH. The new values, given in terms of the thermodynamic temperature (T) by

$$pH(S) = \frac{2073.44}{T} - 13.3270 + 0.045199T - 3.4846 \times 10^{-5}T^2$$

differ, on the average, by 0.003 unit from the results based on the 1944 data of Hamer and Acree.

Key words: Acidity; emf; pH; phthalate buffer; potassium hydrogen phthalate; standard for pH.

1. Introduction

The NBS standard pH scale is fixed by a series of primary standards [1–3][1], the pH(S) values of which are based on precise emf measurements of cells without liquid junction of the type

$$Pt\ or\ Pd;H_2(g,\ 1\ atm)|Buffer + Cl^-|AgCl;Ag \qquad (A)$$

The pH is derived from the emf of cell A, together with a convention [4] relating the numerical value of the activity coefficient of chloride ion to the ionic strength (I) and the temperature, where $0 < I \lesssim 0.1$. It has been shown [3] that, over the pH range 3.5 to 9.2, this scale is internally consistent within 0.006 unit at 25 °C and within 0.013 unit at 10 and 40 °C; that is to say, it is immaterial, within these limits, which of the standards is chosen for the calibration of pH measuring equipment in a given situation.

The solution of potassium hydrogen phthalate, molality 0.05 mol kg^{-1}, is probably the most commonly used of the NBS primary standard reference solutions. It is likewise the single primary standard of the British Standard Institution's pH scale [5]. This solution is easy to prepare from readily available certified material and is reasonably stable. Furthermore, its pH is not markedly sensitive to temperature changes and lies in the weakly acidic region where the practical measurement and control of acidity is often required.

The precise emf measurements, on which the NBS values for this important standard reference solution were originally based, were reported by Hamer, Pinching, and Acree between 1944 and 1946 [6–9]. The potassium hydrogen phthalate used in their work consisted of Standard Reference Materials 84a and 84b. These lots, certified for acidimetry, assayed very close to 100.00 percent. No extensive redetermination of pH(S) over the range 0 to 60 °C was undertaken preparatory to the certification of potassium hydrogen phthalate, SRM 185, as a pH standard, but it was shown [9] that 0.05 m solutions prepared from lots 84a, 84b, 84c, and 185 had the same pH value. The certification of three subsequent lots (SRM 185a, 185b, and 185c) was made by comparison, usually at 25 °C, of the emf of cell A found for the 0.05 molal phthalate solution, with added KCl, with corresponding data obtained in the earlier extensive investigation. The earlier values of pH(S) were then altered uniformly over the temperature range by an amount corresponding to the difference of

[1] Figures in brackets indicate the literature references at the end of this paper.

emf found, at most a few thousandths of a pH unit. It is the purpose of this paper to report the results of a thorough study conducted prior to the certification of SRM 185d, a lot of which was shown by careful assay to have a purity of 99.99 percent and therefore presumably to be essentially identical with the material used in the earlier investigations of Hamer et al.

2. Method

The acidity function $p(a_H\gamma_{Cl})$ is readily calculated from the emf (E) and standard emf (E^0) of cell A by the equation

$$p(a_H\gamma_{Cl}) \equiv -\log(m_H\gamma_H\gamma_{Cl}) = \frac{(E - E^0)F}{RT \ln 10} + \log m_{Cl} \quad (1)$$

the molality of chloride ion (m_{Cl}) being known. As in the later work on the establishment of standard reference buffer solutions [10], three molalities of KCl, namely 0.015, 0.01, and 0.005 mol kg^{-1}, were used. The values of $p(a_H\gamma_{Cl})$ decreased linearly as m_{KCl} increased, and the intercepts $p(a_H\gamma_{Cl})^0$ at $m_{KCl} = 0$ were determined by linear regression analysis:

$$p(a_H\gamma_{Cl}) = p(a_H\gamma_{Cl})^0 - bm_{KCl} \quad (2)$$

The final step in the assignment of standard values, pH(S), to the chloride-free phthalate buffer solution was the calculation of pa_H from $p(a_H\gamma_{Cl})^0$:

$$pH(S) \equiv pa_H = p(a_H\gamma_{Cl})^0 + \log \gamma_{Cl} \quad (3)$$

where γ_{Cl} is fixed by the pH convention proposed by Bates and Guggenheim [4]:

$$\log \gamma_{Cl} = \frac{-AI^{1/2}}{1 + 1.5I^{1/2}} \quad (4)$$

In eq (4), A is the Debye-Hückel slope constant (molality scale) for the temperature in question [3]. This convention is intended to apply over the full temperature range but is restricted to ionic strengths (I) no greater than 0.1 mol kg^{-1}.

3. Experimental Procedures

In general, the experimental methods, including the preparation of the thermal-electrolytic silver-silver chloride electrodes [3] and the techniques of the emf measurements [11], were the same as those described in detail in other publications. Departures from these standard procedures are set forth below.

The platinum bases for the hydrogen electrodes must be coated with palladium black instead of platinum black, in order to minimize reduction of phthalate [12]. Preliminary measurements showed, however, that lightly coated electrodes were more stable than those with a heavier coat of palladium black. Accordingly, the platinum foils were electrolyzed at a current of about 30 mA cm^{-2} for 5 to 10 seconds in a 1 percent solution of palladium chloride acidified with HCl and containing 0.08 g of lead acetate trihydrate per 100 ml of plating solution. A strip of palladium metal served as anode.

Unfortunately, hydrogen electrodes prepared in this way are not as reproducible as are those coated with platinum black (when they can be used), and some instability at the higher temperatures gave testimony to a certain amount of reduction of phthalate. It was therefore necessary to adopt criteria for the rejection of a part of the cell data obtained in this extensive investigation. Each of the cells contained two electrodes of each kind, and the emf was measured both at the beginning and at the end of each temperature series. In general, the criteria for rejection were (a) differences greater than 0.1 mV between pairs of electrodes in the same cell, and (b) differences greater than 0.3 mV between the initial and final measurements at 25 °C. Although some of the cells behaved acceptably over the entire 0 to 60 °C temperature range, for best results it was found necessary to use fresh electrodes and solutions for the range 40 to 60 °C. Thus, the results of only 3 cells out of 27 measured at 10 °C were rejected, whereas 25 of 44 were rejected at 50 °C.

The standard emf E^0 of cell A has been determined in two extensive series of measurements [13, 14]. Inasmuch as there is some evidence that Ag/AgCl electrodes prepared in different laboratories by slightly differing procedures have slightly different potentials, it has been recommended [15] that E^0 be, in effect, redetermined under each set of experimental conditions by measurement of the emf of cell A containing hydrochloric acid, molality 0.01 mol kg^{-1}. Inasmuch as there is substantial agreement that the mean ionic activity coefficient (molality scale) of HCl has the values 0.904 at 25 °C and 0.908 at 0 °C in this solution [15], E^0 can be derived from these emf measurements.

Four investigators, namely V. E. Bower, R. Gary, H. B. Hetzer, and M. Paabo, prepared electrodes from materials used in their own studies, and the group prepared five cells from the same solution of HCl, measuring the emf at three temperatures. The mean results for E were 0.46102 V (standard deviation 0.00004) at 10 °C, 0.46425 V (s.d. 0.00010) at 25 °C, and 0.46623 V (s.d. 0.00005) at 40 °C, from which E^0 is 0.23153, 0.22244, and 0.21216 V at 10, 25, and 40 °C.

These results are higher than those found by Bates and Bower [14]; the differences are 0.11, 0.09, and 0.08 mV at 10, 25, and 40 °C, respectively. Hence, for the present study, E^0 at all temperatures from 0 to 60 °C was obtained by adding 0.1 mV to the values given in the fifth column of table 1, reference [14].

The potassium hydrogen phthalate, SRM 185d, had an assay value of 99.99 percent. It was shown to be equivalent to SRM 84a, one of the lots used by Hamer et al. [6–9], by measuring the emf of a cell of type A containing 0.05m KH phthalate (SRM 84a) + 0.01m KCl at 25, 40, 45, 50, 55, and 60 °C. The emf at these six temperatures differed on the average by only 0.07 mV from the mean values found in the present investigation.

4. Results

The emf data from the cells meeting the criteria outlined above were corrected to 1 atm hydrogen pressure. They are numerous, and to conserve space the individual values (means of two pairs of electrodes in the same cell) have been averaged and the results summarized in table 1, together with the number of cells and the mean deviation from the mean

TABLE 1. *Electromotive force of the cell:* Pd; H_2 (*g, 1 atm*) | KH *Phthalate* (*m* = 0.05), KCl (*m*) | AgCl; Ag *for* m_{KCl} = *0.005, 0.01, and 0.015 mol* kg^{-1} *from 0 to 60°C (in volts)*

t/°C	m_{KCl} = 0.005			m_{KCl} = 0.01			m_{KCl} = 0.015		
	No. of cells	*E*/volts (mean)	Mean dev. [a]	No. of cells	*E*/volts (mean)	Mean dev. [a]	No. of cells	*E*/volts (mean)	Mean dev. [a]
0	6	0.58311	0.03	8	0.56662	0.07	10	0.55695	0.09
5	6	0.58666	0.04	8	0.56986	0.06	10	0.55996	0.07
10	6	0.59015	0.03	8	0.57304	0.06	10	0.56297	0.07
15	6	0.59366	0.05	8	0.57622	0.07	10	0.56601	0.08
20	6	0.59713	0.06	8	0.57939	0.06	10	0.56900	0.08
25	12	0.60060	0.06	12	0.58257	0.04	17	0.57199	0.09
30	6	0.60402	0.09	8	0.58565	0.07	10	0.57493	0.10
35	6	0.60742	0.13	8	0.58873	0.06	11	0.57786	0.12
40	6	0.61104	0.15	6	0.59209	0.05	8	0.58090	0.08
45	6	0.61444	0.12	6	0.59519	0.07	7	0.58385	0.13
50	6	0.61787	0.09	6	0.59832	0.10	7	0.58680	0.13
55	6	0.62131	0.09	6	0.60144	0.10	7	0.58969	0.15
60	6	0.62474	0.08	6	0.60460	0.10	7	0.59266	0.12

[a] Mean deviation from the mean value of *E*, in mV.

emf, in mV. Only the initial results at 25 °C are given; the final results at this temperature were not used.

Values of the acidity function $p(a_H\gamma_{Cl})$ were calculated by eq (1) and the intercepts $p(a_H\gamma_{Cl})^0$ and slopes *b* obtained by linear regression analysis; the relationship is shown in eq (2). This procedure was carried out in two ways: first, by use of the average $p(a_H\gamma_{Cl})$ values computed from the average emf's of table 1, and second, by use of the entire population of $p(a_H\gamma_{Cl})$ values, that is, those derived from the emf of each individual cell. The intercepts obtained by the two procedures differed by considerably less than 0.001 pH unit. The results collected in table 2 are nonetheless those obtained by treating each data point individually. The standard deviations of the intercepts and slopes are given, and the standard deviation for regression, expressed in mV, appears in the last column.

TABLE 2. *Linear regression analysis. Constants of equation (2)*

t/°C	*n*	$p(a_H\gamma_{Cl})^0$	*b*	s.d. (intercept)	s.d. (slope)	s.d. (regression) [a]
0	24	4.0944	0.612	0.0006	0.049	0.05
5	24	4.0880	0.659	0.0008	0.070	0.08
10	24	4.0857	0.669	0.0008	0.071	0.08
15	24	4.0858	0.630	0.0009	0.082	0.09
20	24	4.0881	0.627	0.0010	0.083	0.10
25	41	4.0946	0.654	0.0006	0.054	0.08
30	24	4.1005	0.641	0.0012	0.101	0.12
35	25	4.1075	0.612	0.0013	0.115	0.13
40	20	4.1223	0.788	0.0012	0.108	0.12
45	19	4.1341	0.746	0.0014	0.128	0.15
50	19	4.1482	0.749	0.0013	0.121	0.13
55	19	4.1638	0.858	0.0016	0.144	0.17
60	19	4.1803	0.818	0.0013	0.116	0.14

[a] Expressed in mV.

Application of the convention for γ_{Cl} set forth in eq (4) enables one to derive pH(S) from $p(a_H\gamma_{Cl})^0$ by eq (3). The ionic strength (*I*) required for this purpose was calculated from the ionic compositions of potassium hydrogen phthalate solutions; these have been obtained by Hamer, Pinching, and Acree [9] from K_1 and K_2 for phthalic acid. The ionic strength is nearly constant over the temperature range 0 to 60 °C, varying only from 0.0532 to 0.0534 mol kg^{-1}; log γ_{Cl} decreases from −0.0843 at 0 °C to −0.0934 at 60 °C. The values of pH(S) found in this way are listed in the third column of table 3. With the aid of the OMNITAB computer program, they were fitted to the equation

$$pH(S) = \frac{2073.44}{T} - 13.3270 + 0.045199T - 3.4846 \times 10^{-5}T^2 \quad (5)$$

where *T* is the thermodynamic temperature. Calculated values of pH(S) are given in the last column of the table. From a comparison of the experimental pH(S) with that calculated by eq (5), there is a standard deviation for regression of 0.0010 unit.

TABLE 3. *pH(S) values for the potassium hydrogen phthalate solution, molality = 0.05 mol* kg^{-1}*, from 0 to 60°C*

t/°C	NBS [a]	Present Work	
		exp.	calc. [b]
0	4.003	4.010_1	4.0100
5	3.999	4.003_1	4.0035
10	3.998	4.000_2	4.0001
15	3.999	3.999_6	3.9994
20	4.002	4.001_2	4.0014
25	4.008	4.007_0	4.0058
30	4.015	4.012_1	4.0123
35	4.024	4.018_4	4.0208
40	4.035	4.032_4	4.0311
45	4.047	4.043_3	4.0431
50	4.060	4.056_6	4.0565
55	4.075	4.071_4	4.0712
60	4.091	4.086_9	4.0872

[a] From the emf measurements of Hamer et al. [6] ; see reference [1].
[b] Calculated with use of equation (5).

5. Discussion

The values of pH(S) labeled "NBS" in table 3 were derived [1] from the emf measurements of Hamer and Acree [6]. The

original emf data, reported in international volts, were corrected to the absolute scale and $p(a_H\gamma_{Cl})$ obtained with the aid of E^0 from the study of Bates and Bower [14]. The pH(S) values resulting from the application of the γ_{Cl} convention to $p(a_H\gamma_{Cl})^0$ were fitted to a four-constant equation of the same form as eq (5). The mean difference between experimental and calculated pH(S) at the 13 temperatures was 0.002_1. The smoothed values from this equation are listed in the second column of table 3. In general, the present results for temperatures below 20 °C are slightly higher than those derived from the earlier data, and they are lower when the temperature lies between 20 and 60 °C. Nevertheless, the mean difference for all 13 temperatures is only 0.003_3 unit.

In 1946, Hamer, Pinching, and Acree [9] calculated the pa_H values of solutions of potassium hydrogen phthalate at eight different molalities, 0.001 to 0.2 mol kg^{-1}, from K_1 and K_2 for phthalic acid and ionic activity coefficients estimated in a manner different from the convention of eq (4). At a molality of 0.05 mol kg^{-1}, the values obtained in this way are in somewhat better agreement with those of the present study than are the values labeled "NBS" in table 3. The mean difference is 0.002_2 at the 13 temperatures; if 55 and 60 °C (where the differences are 0.006 and 0.010 pH unit, respectively) are omitted, the mean difference is only 0.001 unit.

The largest differences between the values in the second and third columns of table 3 occur at 0 and 35 °C. In this connection, it is noteworthy that the experimental value from the earlier work is 4.006 at 0 °C; here smoothing has accentuated the discrepancy. Furthermore, the values of the present study for the range 40 to 60 °C are based largely on a different set of cells and solutions from those for 35 °C and below. The greatest disparity between experimental and calculated pH(S), namely 0.0024 unit, occurs at 35 °C, and it seems likely that the experimental result at this temperature is slightly low. No explanation for this inconsistency can be found, yet its existence appears to be sufficient justification to regard the smoothed values of the last column as the more reliable and self-consistent set.

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Atlas of the I_2 Spectrum from 19 000 to 18 000 cm^{-1} *

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A line identification band atlas is presented for a 1000 cm^{-1} segment, from 19 000 to 18 000 cm^{-1}, of the molecular iodine absorption spectrum. Each page of the atlas covers a 20 cm^{-1} region of the spectrum and contains a CALCOMP produced photodensitometer trace of the spectrum together with accompanying tabular identification data. The tabular data includes: line identification numbers, observed wavenumbers, calculated wavenumbers, and rotational and vibrational assignments.

Key words: High-resolution spectrum; iodine spectrum; line identification atlas; rovibronic assignments; spectral analysis; visible absorption spectroscopy.

1. Introduction

The present article represents the first part of a projected band atlas of the $B^3\Pi_{0^+_u} - X^1\Sigma^+_g$ visible absorption spectrum of the iodine molecule. The region from 19 000 to 18 000 cm^{-1} (from 5261.7 to 5554.0 Å) was chosen for initial study because it exhibits neither the complications of many close-lying upper state vibrational levels found at higher wavenumbers nor the complications of strong hot bands found at lower wavenumbers.

The visible spectrum of I_2 has been extensively studied in the past, of course, and it is not our purpose here to trace the numerous developments in the understanding of that spectrum. Suffice it to say that for the present atlas we have relied heavily on the paper by Wei and Tellinghuisen [1].[1] Measurements here for $J < 100$ agree with the spectrum calculated from the constants of [1] to within ± 0.03 cm^{-1} in most cases and ± 0.01 cm^{-1} in many cases. The vibrational numbering adopted by Wei and Tellinghuisen and used also in the present atlas is that determined by Steinfeld, Zare, Jones, Lesk, and Klemperer [2] and confirmed by Brown and James [3].

We have very recently learned, through a preprint from Gerstenkorn, Luc, and Perrin [4] on the 5350 Å band of iodine and through subsequent correspondence [5], that a study similar to ours is being carried out at the Laboratoire Aimé Cotton in France. The French investigators have measured the iodine visible spectrum interferometrically, obtaining significantly better absolute measurement accuracy, though no appreciable difference in spectral resolution, since the latter is limited in both studies by the molecular line widths. We have received permission [5] to reproduce here (in fig. 1) their display of differences between our measurements and theirs.

The actual band atlas, presented below in figure 2, consists of 50 pages, each containing a 20 cm^{-1} portion of the spectrum, augmented by a 0.5 cm^{-1} overlap at each end. The figure at the top of each page is a CALCOMP display of a photodensitometer trace of the original photographic record of the spectrum. The tabular material below each spectral trace contains a line identification number, a measured wavenumber, the last four digits of a calculated wavenumber, a rotational assignment, and a vibrational assignment. Measured wavenumbers are presented in the atlas in decreasing numerical order, corresponding to the established optical spectroscopy prescription of "red to the right." More detailed comments on the atlas are presented in section 3 below.

2. Apparatus[2]

Each I_2 band for which absorption lines fall in the region of the atlas has been photographed, measured and assigned in its entirety. Therefore, the bands actually analyzed extend from about 19 500 to 17 700 cm^{-1}.

The spectral plates were photographed in the 10th, 11th, or 12th order of a 3.34 m Czerny-Turner spectrograph constructed at the National Bureau of Standards by Dr. J. Reader [6, 7]. The spectrograph is equipped with a 300 line/mm, 220 mm long grating blazed at 6 μm, and is capable of delivering close [8] to its theoretical resolving power (726 000 in 11th order). Unfortunately, the Doppler width of I_2 (0.014 cm^{-1} FWHM at 18 500 cm^{-1} and 25 °C), the quadrupole hyperfine pattern width (~0.030 cm^{-1}), and the instrumental resolution of the photodensitometer prevent this large resolving power from being fully utilized. The measured I_2 linewidths (FWHM) in the spectra presented are of the order of 0.055 cm^{-1}, corresponding to an effective resolving power of approximately 350 000. Exposure times with a high-pressure xenon source lamp and Kodak V-F plates varied from 5 to 20 min. Iodine pressure in the room-temperature, single-pass, 1-m absorption cell was controlled

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[1] Figures in brackets indicate the literature references at the end of this paper.

[2] In order to adequately describe materials and experimental procedures, it was occasionally necessary to identify commercial products by manufacturer's name or label. In no instance does such identification imply endorsement by the National Bureau of Standards, nor does it imply that the particular product or equipment is the best available for the purpose.

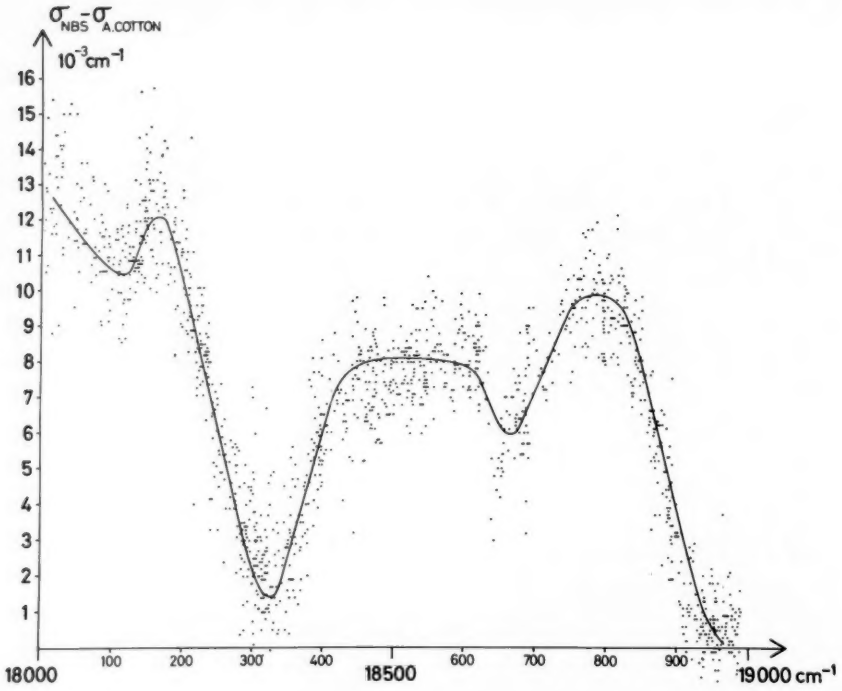


FIGURE 1. *A correction curve for the wavenumbers in this atlas kindly supplied by Gerstenkorn and Luc [5], who plot differences between our grating measurements of the* I_2 *absorption spectrum* (σ_{NBS}) *and their interferometric measurements* ($\sigma_{A.COTTON}$).

by a sidearm cooled to temperatures in the range −11 °C to +6 °C. Iodine sidearm temperatures and exposure times are indicated in table 1 for each of the five plates used in the spectral illustrations below.

TABLE 1. *Iodine sidearm temperatures and exposure times for the spectral figures in this atlas*

Spectral region	*T* °C	Exposure time
19 000–18 920	−6	5 minutes
18 920–18 640	−6	7 minutes
18 640–18 380	−6	5 minutes
18 380–18 180	−11	6.5 minutes
18 180–18 000	−6	6.5 minutes

The I_2 spectrum was measured against thorium emission line standards taken from the extensive catalog of R. Zalubus [9, 10]. Many of the stronger lines have been interferometrically measured, and thorium exposure times were kept short enough to eliminate most of the weaker "grating" lines, but long enough to insure from 20 to 40 standards across a plate encompassing 250 cm^{-1}. Unfortunately, exposure times could not be reduced enough to eliminate all problems with self-reversal, which the computer software described below was not equipped to handle. The interferometrically measured thorium lines are thought to be reliable to ± 0.002 cm^{-1} [10], but our third order polynomial fits across one plate (as well as the somewhat higher order fits also examined) gave standard deviations near 0.0045 cm^{-1}. We believe our large standard deviation arises because a few of the thorium emission linewidths (FWHM) approached 0.2 cm^{-1}, or about four times the I_2 absorption linewidths. Our inability to achieve better polynomial fits to the thorium standards represents the principal limitation to obtaining more accurate measurements of the present I_2 spectrum. Based on these considerations, we estimated the I_2 measured wavenumbers to have an absolute accuracy of ± 0.015 cm^{-1}. This estimate was confirmed just prior to publication by the more accurate measurements of Gerstenkorn, Luc, and Perrin [4, 5], as shown in figure 1.

The photographic plates were measured on a Grant comparator, which automatically digitally recorded on magnetic tape photodensitometer readings at equidistant 3 μm intervals (about 1/20 of the I_2 FWHM) for both the unknown (I_2) and standard (thorium) channels. The photodensitometer slit width was equivalent to approximately 9 μm on the photographic plates. The magnetic tape record of the photographic plate density was then reduced to a sequentially numbered I_2 line list in cm^{-1} and a CALCOMP spectral trace, using slightly modified versions of computer programs originally written by Dr. A. Maki [11] for reducing infrared data. Subroutines in his programs automatically locate the centers of absorption or emission lines in the two channels, fit the unknown channel against the standard channel, and invoke various criteria (excessive breadth, weakness, etc.) to eliminate undesirable lines from further consideration.

3. Detailed Remarks on the Atlas

To the extent practical, spectra are reproduced in figure 2 with a wavenumber scale equal to 1 cm^{-1} per cm.

The intensity scale is rather arbitrary. Iodine pressures and exposure times were chosen to minimize saturation of the strongest lines and maximize contrast between bands originating in the $v'' = 0$ level and bands originating in $v'' = 1$ and 2. Nonetheless, an intensity alternation approximating the theoretical value of 7:5 for odd:even values of J is clearly visible in unblended portions of both the strong and weak branches.

Unfortunately, it proved impossible to photograph and develop an entire set of plates without encountering some small pinholes and/or scratches in the emulsion, which ultimately show up as apparent absorption lines in the CALCOMP spectrum. It was decided to present as large a portion of spectrum as possible from a single plate in order to preserve as much relative intensity information as possible, rather than to present only blemish-free regions from a large number of plates. We have thus attempted to locate as many of these false absorption lines as possible, by examining each plate for blemishes and by comparing CALCOMP spectra obtained from different plates. We have indicated the "correct" spectrum in the region of false absorption lines thus identified by hand-drawn dotted lines.

The columns headed LINE contain the artitrary sequential line identification number for "ticked" lines in the spectral figures, or contain a blank for "unticked" lines.

The columns headed OBS CM-1 contain measured wavenumbers for each line. Measurements for ticked lines were obtained by processing the spectrum actually shown in the figure. Measurements for unticked lines were obtained from other plates, taken at significantly higher iodine pressures to enhance the weaker lines without concern for the attendant saturation and broadening of the stronger lines. Occasional asterisk entries in this column indicate a line clearly visible in the spectral figure for which an assignment and calculated value, but no measurement, is available.

Each column headed CALC contains the last four digits of calculated wavenumbers approximately equal to the measured wavenumbers in the OBS column immediately to the left. If more than one transition is calculated to lie within the contour of a given measured line in the spectral figure, these several calculated values are given in order of decreasing wavenumber immediately to the right and below the measured line in question. For each branch of the $(v' - 0)$ and $(v' - 1)$ bands, no calculated transitions are presented having J values above the last observed line in the branch (as discussed below). For each branch of the $(v' - 2)$ bands and the $(31 - 1)$ band, no calculated transitions are presented having J values below the first observed line or above the last observed line in the branch. Occasional asterisk entries in this column indicate false absorption lines introduced by the emulsion blemishes described above.

The columns headed ASSIGNMENT contain the rotational branch (P,R) and J assignment followed by the vibrational $(v' - v'')$ assignment of the calculated wavenumber immediately to the left, or contain the word ARTIFACT to indicate a false absorption line.

In almost all cases, the contour of a given spectral line can be understood by taking into account the one or more calculated values associated with it, together with intensity information obtained from examination of nearby unblended lines in the same branch(es).

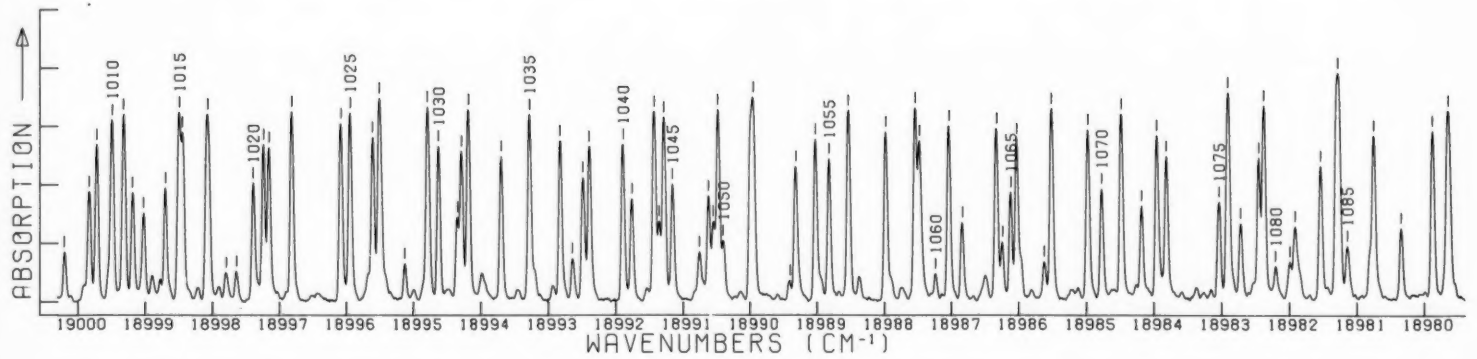
Calculated wavenumbers presented in the CALC columns were obtained from least squares fits of unblended P and R branch lines for each individual $(v' - v'')$ band. Unblended lines were chosen by visual inspection, taking into consideration the intensity alternation and overall intensity variation expected within a given branch, and the essentially constant linewidth expected in each spectral region. For each branch of each band it proved impossible to find unblended lines below a certain minimum J value, and impossible to find lines at all above a certain maximum J value. Thus, for any branch, three types of calculated values can be defined: those interpolated between the minimum and maximum J values used in the fit, those extrapolated to low J beyond lines used in the fit, and those extrapolated to high J beyond lines used in the fit. In no cases are calculated values corresponding to high J extrapolations presented in this atlas. For $(v' - 0)$ and most $(v' - 1)$ bands, all calculated values corresponding to low J extrapolations are presented. For the much weaker $(v' - 2)$ bands and the $(31 - 1)$ band no calculated values corresponding to low J extrapolations are presented.

Least squares fits of the unblended lines in each individual $(v' - v'')$ band were carried out by varying the parameters ν_0, B', B'', D', D'', H', H'', and sometimes L' in equations of the form

$$\begin{aligned} R(J) &= + B'_{v'}(J+1)(J+2) - D'_{v'}(J+1)^2(J+2)^2 \\ &\quad + H'_{v'}(J+1)^3(J+2)^3 + L'_{v'}(J+1)^4(J+2)^4 \\ &\quad - B''_{v''}J(J+1) + D''_{v''}J^2(J+1)^2 \\ &\quad - H''_{v''}J^3(J+1)^3 + \nu_0(v',v'') \end{aligned} \tag{1}$$

$$\begin{aligned} P(J) &= + B'_{v'}J(J-1) - D'_{v'}J^2(J-1)^2 \\ &\quad + H'_{v'}J^3(J-1)^3 + L'_{v'}J^4(J-1)^4 \\ &\quad - B''_{v''}J(J+1) + D''_{v''}J^2(J+1)^2 \\ &\quad - H''_{v''}J^3(J+1)^3 + \nu_0(v',v''). \end{aligned}$$

Values of the parameters and standard deviations obtained from these band-by-band least squares fits, and of J_{min}, J_{max} and the number of lines in each branch included in the fit, are given in table 2. *The reader is emphatically warned that these band-by-band parameters must not be treated as true molecular constants.* In particular, they should not be used to extrapolate branches beyond J values used in the fits (though with some misgivings we ourselves have violated this precept in presenting calculated values for all low J lines in the $(v' - 0)$ and $(v' - 1)$ heads). Neither should the band-by-band parameters be further reduced to obtain structural information for the I_2 molecule. These parameters are useful, however, and have been used in this atlas, to calculate *interpolated* line positions within a branch; they are presented in table 2 with sufficient precision to permit such back-calcula-



LINE	OBS CM-1	CALC	ASSIGNMENT
1007	19000.201	0.204	R129 (40-0)
1008	18999.829	9.915	R151 (43-0)
		9.835	R119 (39-0)
		9.825	P127 (40-0)
1009	18999.714	9.714	P 36 (35-0)
1010	18999.487	9.547	P143 (42-0)
		9.486	P 69 (36-0)
1011	18999.316	9.378	R161 (45-0)
		9.315	R 39 (35-0)
1012	18999.184	9.182	R107 (38-0)
1013	18999.021	9.022	P117 (39-0)
	18998.896		
	18998.780	8.781	R145 (42-0)
1014	18998.698	8.699	R 92 (37-0)
1015	18998.488	8.490	P 37 (35-0)
1016	18998.439	8.435	R 72 (36-0)
	18998.210		
1017	18998.071	8.080	R 40 (35-0)
		8.047	P105 (38-0)
	18997.902	7.900	P155 (44-0)
1018	18997.793	7.799	P136 (41-0)
1019	18997.635	7.640	R138 (41-0)
1020	18997.384	7.385	P 90 (37-0)
1021	18997.233	7.234	P 38 (35-0)
1022	18997.152	7.152	P 70 (36-0)
1023	18996.813	6.813	R 41 (35-0)
1024	18996.082	6.082	R 73 (36-0)

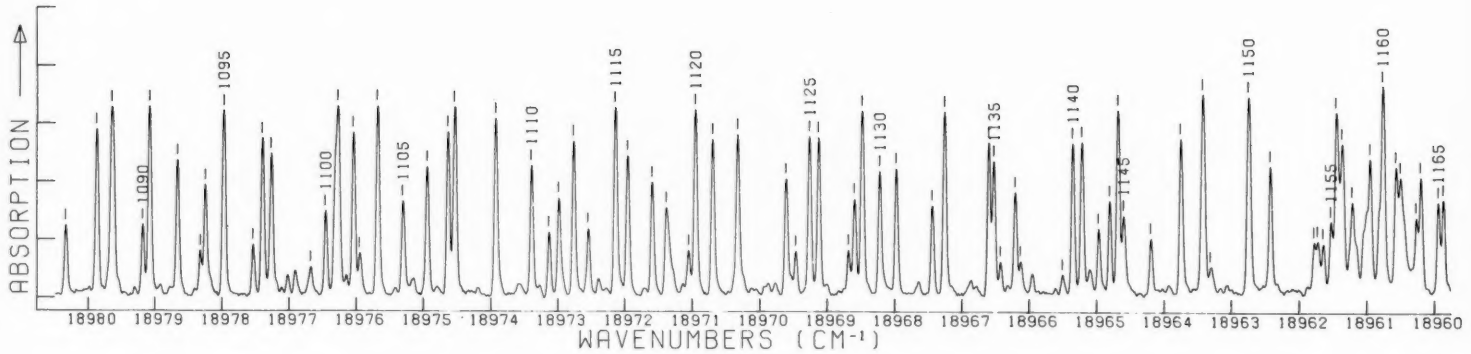
LINE	OBS CM-1	CALC	ASSIGNMENT
1025	18995.945	5.946	P 39 (35-0)
	18995.679	5.687	P160 (45-0)
		5.683	R157 (44-0)
1026	18995.607	5.612	R120 (39-0)
		5.608	R 93 (37-0)
1027	18995.505	5.513	R 42 (35-0)
		5.499	R130 (40-0)
		5.487	R108 (38-0)
		5.413	P150 (43-0)
1028	18995.127	5.130	P128 (40-0)
	18995.000		
1029	18994.786	4.802	P118 (39-0)
		4.784	P 71 (36-0)
1030	18994.625	4.626	P 40 (35-0)
1031	18994.347	4.349	P106 (38-0)
1032	18994.285	4.285	P 91 (37-0)
1033	18994.182	4.181	R 43 (35-0)
	18993.985	3.983	P144 (42-0)
		3.929	R152 (43-0)
1034	18993.697	3.696	R 74 (36-0)
1035	18993.273	3.273	P 41 (35-0)
	18993.196	3.190	R146 (42-0)
	18992.930		
1036	18992.817	2.817	R 44 (35-0)
1037	18992.635	2.641	P137 (41-0)
		2.624	R162 (45-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
1038	18992.478	2.481	R 94 (37-0)
		2.464	R139 (41-0)
1039	18992.382	2.383	P 72 (36-0)
1040	18991.889	1.889	P 42 (35-0)
1041	18991.755	1.755	R109 (38-0)
CALC	*********	1.540	P156 (44-0)
1042	18991.421	1.421	R 45 (35-0)
1043	18991.348	1.350	R121 (39-0)
1044	18991.275	1.276	R 75 (36-0)
1045	18991.149	1.149	P 92 (37-0)
1046	18990.750	0.754	R131 (40-0)
1047	18990.613	0.614	P107 (38-0)
1048	18990.542	0.544	P119 (39-0)
1049	18990.472	0.472	P 43 (35-0)
1050	18990.394	0.396	P129 (40-0)
1051	18989.955	9.993	R 46 (35-0)
		9.948	P 73 (36-0)
	18989.590		
1052	18989.408	9.417	P151 (43-0)
1053	18989.319	9.320	R 95 (37-0)
		9.278	R158 (44-0)
1054	18989.024	9.024	P 44 (35-0)
	18988.948	8.939	P161 (45-0)
1055	18988.821	8.822	R 76 (36-0)
1056	18988.532	8.532	R 47 (35-0)
	18988.375	8.376	P145 (42-0)

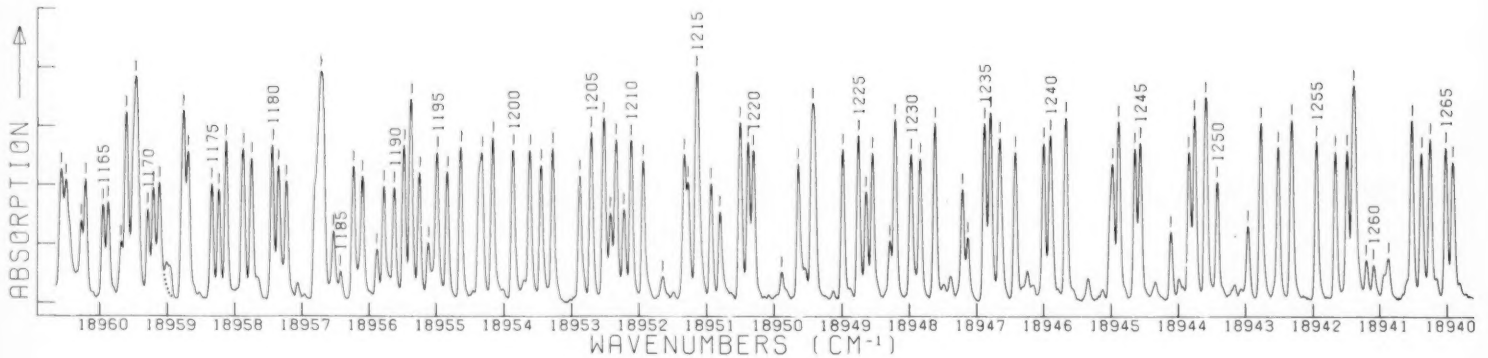
LINE	OBS CM-1	CALC	ASSIGNMENT
1057	18987.980	7.986	R110 (38-0)
		7.979	P 93 (37-0)
	18987.903	7.897	R153 (43-0)
1058	18987.543	7.556	R147 (42-0)
		7.543	P 45 (35-0)
1059	18987.480	7.480	P 74 (36-0)
		7.441	P158 (41-0)
1060	18987.242	7.246	R140 (41-0)
1061	18987.041	7.050	R122 (39-0)
		7.039	R 48 (35-0)
1062	18986.842	6.844	P108 (38-0)
	18986.503		
1063	18986.334	6.335	R 77 (36-0)
1064	18986.246	6.249	P120 (39-0)
1065	18986.122	6.123	R 96 (37-0)
1066	18986.030	6.030	P 46 (35-0)
	18985.971	5.969	R132 (40-0)
	18985.817	5.820	R163 (45-0)
1067	18985.619	5.622	P130 (40-0)
1068	18985.514	5.514	R 49 (35-0)
	18985.130	5.132	P157 (44-0)
1069	18984.978	4.978	P 75 (36-0)
1070	18984.772	4.774	P 94 (37-0)
1071	18984.485	4.485	P 47 (35-0)
	18984.268		
1072	18984.182	4.181	R111 (38-0)
1073	18983.957	3.956	R 50 (35-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
1074	18983.814	3.814	R 78 (36-0)
	18983.373	3.376	P152 (43-0)
	18983.155		
1075	18983.035	3.036	P109 (38-0)
1076	18982.900	2.907	P 48 (35-0)
		2.892	R 97 (37-0)
		2.825	R159 (44-0)
1077	18982.711	2.725	P146 (42-0)
		2.713	R123 (39-0)
1078	18982.443	2.443	P 76 (36-0)
1079	18982.366	2.367	R 51 (35-0)
1080	18982.198	2.201	P139 (41-0)
		2.140	P162 (45-0)
1081	18981.986	1.986	R141 (41-0)
1082	18981.910	1.915	P121 (39-0)
		1.878	R148 (42-0)
		1.819	R154 (43-0)
1083	18981.533	1.534	P 95 (37-0)
1084	18981.278	1.298	P 49 (35-0)
		1.260	R 79 (36-0)
1085	18981.139	1.144	R133 (40-0)
1086	18980.745	0.809	P131 (40-0)
		0.745	R 52 (35-0)
1087	18980.339	0.340	R112 (38-0)
1088	18979.875	9.875	P 77 (36-0)
1089	18979.648	9.656	P 50 (35-0)
		9.625	R 98 (37-0)

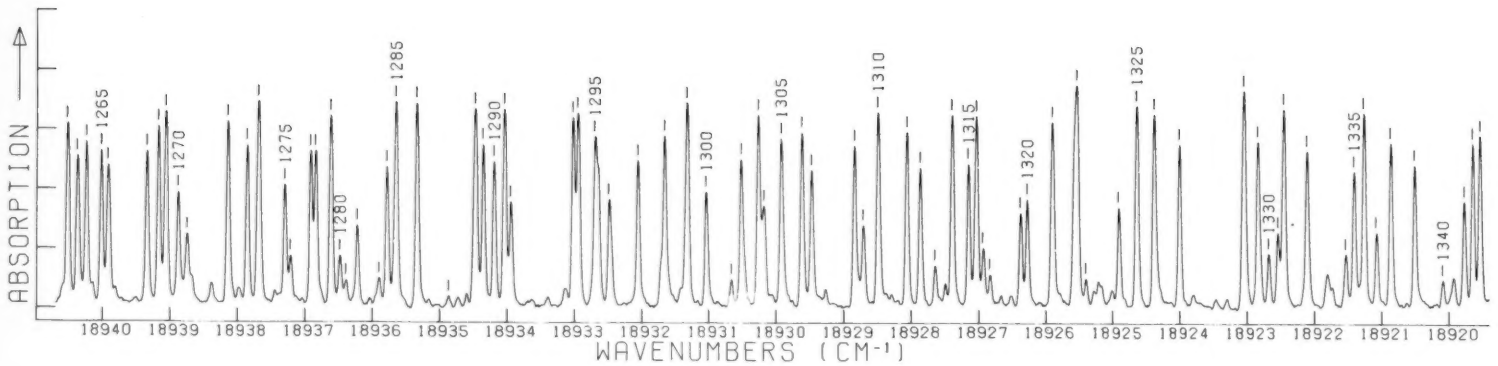
FIGURE 2. *Line identification atlas of the* I_2 *absorption spectrum from 19 000 to 18 000* cm^{-1}.
See section 3 of the text for details.



LINE	OBS CM-1	CALC	ASSIGNMENT
1087	18980.339	0.340	R112 (38-0)
1088	18979.875	9.875	P 77 (36-0)
1089	18979.648	9.656	P 50 (35-0)
		9.625	R 98 (37-0)
	18979.558		
1090	18979.191	9.193	P110 (38-0)
1091	18979.090	9.090	R 53 (35-0)
1092	18978.671	8.672	R 80 (36-0)
1093	18978.333	8.337	R124 (39-0)
1094	18978.258	8.259	P 96 (37-0)
1095	18977.981	7.982	P 51 (35-0)
1096	18977.541	7.544	P122 (39-0)
1097	18977.403	7.403	R 54 (35-0)
1098	18977.273	7.272	P 78 (36-0)
	18977.031	7.031	P147 (42-0)
	18976.916	6.919	P140 (41-0)
1099	18976.679	6.684	R142 (41-0)
1100	18976.461	6.462	R113 (38-0)
1101	18976.280	6.323	R 99 (37-0)
		6.323	R160 (44-0)
		6.279	R134 (40-0)
		6.275	P 52 (35-0)
	18976.157	6.156	R149 (42-0)
1102	18976.049	6.050	R 81 (36-0)
1103	18975.953	5.956	P132 (40-0)
1104	18975.686	5.695	R155 (43-0)
		5.684	R 55 (35-0)
1105	18975.310	5.313	P111 (38-0)
		5.291	P163 (45-0)
1106	18974.949	4.950	P 97 (37-0)
1107	18974.636	4.637	P 79 (36-0)
1108	18974.537	4.537	P 53 (35-0)
1109	18973.930	3.933	R 56 (35-0)
		3.922	R125 (39-0)
1110	18973.394	3.394	R 82 (36-0)
1111	18973.134	3.135	P123 (39-0)
1112	18972.985	2.986	R100 (37-0)
1113	18972.766	2.766	P 54 (35-0)
1114	18972.547	2.547	R114 (38-0)
	18972.399		
1115	18972.149	2.149	R 57 (35-0)
1116	18971.966	1.967	P 80 (36-0)
1117	18971.601	1.605	P 98 (37-0)
		1.596	P141 (41-0)
1118	18971.388	1.397	P112 (38-0)
		1.373	R135 (40-0)
		1.341	R143 (41-0)
		1.294	P148 (42-0)
	18971.152		
1119	18971.060	1.064	P133 (40-0)
1120	18970.962	0.962	P 55 (35-0)
1121	18970.704	0.705	R 83 (36-0)
1122	18970.333	0.390	R150 (42-0)
		0.332	R 58 (35-0)
	18969.881		
	18969.773	9.773	R161 (44-0)
1123	18969.612	9.614	R101 (37-0)
1124	18969.466	9.525	R156 (43-0)
		9.470	R126 (39-0)
1125	18969.263	9.264	P 81 (36-0)
1126	18969.127	9.127	P 56 (35-0)
1127	18968.683	8.688	P124 (39-0)
1128	18968.595	8.595	R115 (38-0)
1129	18968.484	8.483	R 59 (35-0)
		8.392	P164 (45-0)
1130	18968.225	8.225	P 99 (37-0)
1131	18967.981	7.982	R 84 (36-0)
	18967.646		
1132	18967.443	7.444	P113 (38-0)
1133	18967.259	7.259	P 57 (35-0)
1134	18966.603	6.602	R 60 (35-0)
1135	18966.527	6.528	P 82 (36-0)
1136	18966.427	6.428	R136 (40-0)
1137	18966.208	6.231	P142 (41-0)
		6.207	R102 (37-0)
1138	18966.128	6.131	P134 (40-0)
	18965.957	5.955	R144 (41-0)
1139	18965.507	5.513	P149 (42-0)
1140	18965.358	5.358	P 58 (35-0)
1141	18965.224	5.225	R 85 (36-0)
	18965.108		
1142	18964.976	4.978	R127 (39-0)
1143	18964.809	4.810	P100 (37-0)
1144	18964.689	4.688	R 61 (35-0)
1145	18964.604	4.607	R116 (38-0)
		4.581	R151 (42-0)
1146	18964.198	4.202	P125 (39-0)
1147	18963.757	3.758	P 83 (36-0)
1148	18963.429	3.455	P114 (38-0)
		3.425	P 59 (35-0)
1149	18963.312	3.308	R157 (43-0)
1150	18962.750	2.764	R103 (37-0)
		2.742	R 62 (35-0)
1151	18962.434	2.434	R 86 (36-0)
1152	18961.783	1.796	R 1 (34-0)
		1.784	R 0 (34-0)
		1.777	R 2 (34-0)
1153	18961.729	1.727	R 3 (34-0)
1154	18961.649	1.666	P 1 (34-0)
		1.645	R 4 (34-0)
1155	18961.535	1.560	P 2 (34-0)
		1.532	R 5 (34-0)
1156	18961.456	1.460	P 60 (35-0)
		1.443	R137 (40-0)
		1.442	P165 (45-0)
		1.423	P 3 (34-0)
1157	18961.366	1.388	R 6 (34-0)
		1.360	P101 (37-0)
1158	18961.216	1.255	P 4 (34-0)
		1.213	R 7 (34-0)
	18961.167	1.159	P135 (40-0)
1159	18960.954	1.055	P 5 (34-0)
		1.006	R 8 (34-0)
		0.954	P 84 (36-0)
1160	18960.765	0.824	P 6 (34-0)
		0.824	P143 (41-0)
		0.768	R 9 (34-0)
		0.763	R 63 (35-0)
1161	18960.571	0.581	R117 (38-0)
		0.562	P 7 (34-0)
1162	18960.503	0.527	R145 (41-0)
		0.499	R 10 (34-0)
		0.449	R128 (39-0)
1163	18960.268	0.269	P 8 (34-0)
1164	18960.202	0.199	R 11 (34-0)
1165	18959.943	9.944	P 9 (34-0)
1166	18959.867	9.867	R 12 (34-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
1161	18960.571	0.581	R117 (38-0)
		0.562	P 7 (34-0)
1162	18960.503	0.527	R145 (41-0)
		0.499	R 10 (34-0)
		0.449	R128 (39-0)
1163	18960.268	0.269	P 8 (34-0)
1164	18960.202	0.199	R 11 (34-0)
1165	18959.943	9.944	P 9 (34-0)
1166	18959.867	9.867	R 12 (34-0)
1167	18959.677	9.688	P150 (42-0)
		9.679	P126 (39-0)
1168	18959.604	9.609	R 87 (36-0)
		9.589	P 10 (34-0)
1169	18959.463	9.504	R 13 (34-0)
		9.462	P 61 (35-0)
		9.429	P115 (38-0)
1170	18959.285	9.286	R104 (37-0)
1171	18959.202	9.201	P 11 (34-0)
1172	18959.111	9.110	R 14 (34-0)
		*****	ARTIFACT
1173	18958.756	8.783	P 12 (34-0)
		8.751	R 64 (35-0)
		8.726	R152 (42-0)
1174	18958.686	8.684	R 15 (34-0)
1175	18958.333	8.333	P 13 (34-0)
1176	18958.228	8.227	R 16 (34-0)
1177	18958.115	8.116	P 85 (36-0)
1178	18957.864	7.875	P102 (37-0)
		7.852	P 14 (34-0)
1179	18957.740	7.739	R 17 (34-0)
	18957.653		
1180	18957.433	7.432	P 62 (35-0)
1181	18957.340	7.340	P 15 (34-0)
1182	18957.220	7.220	R 18 (34-0)
	18957.059	7.044	R158 (43-0)
1183	18956.700	6.797	P 16 (34-0)
		6.750	R 88 (36-0)
		6.707	R 65 (35-0)
		6.669	R 19 (34-0)
1184	18956.520	6.519	R118 (38-0)
1185	18956.417	6.417	R138 (40-0)
1186	18956.222	6.222	P 17 (34-0)
1187	18956.087	6.147	P136 (40-0)
		6.087	R 20 (34-0)
1188	18955.875	5.880	R129 (39-0)
1189	18955.770	5.773	R105 (37-0)
1190	18955.616	5.616	P 18 (34-0)
1191	18955.474	5.474	R 21 (34-0)
1192	18955.369	5.375	P144 (41-0)
		5.369	P 63 (35-0)
		5.366	P116 (38-0)
1193	18955.244	5.244	P 86 (36-0)
1194	18955.112	5.117	P127 (39-0)
		5.057	R146 (41-0)
1195	18954.979	4.979	P 19 (34-0)
1196	18954.829	4.829	R 22 (34-0)
1197	18954.630	4.631	R 66 (35-0)
CALC	*********	4.442	P166 (45-0)
1198	18954.316	4.355	P103 (37-0)
		4.310	P 20 (34-0)
1199	18954.153	4.153	R 23 (34-0)
1200	18953.856	3.857	R 89 (36-0)
		3.819	P151 (42-0)
	18953.697		
1201	18953.610	3.610	P 21 (34-0)
1202	18953.445	3.446	R 24 (34-0)
1203	18953.275	3.274	P 64 (35-0)
1204	18952.878	2.879	P 22 (34-0)
		2.828	R153 (42-0)
1205	18952.707	2.707	R 25 (34-0)
1206	18952.521	2.521	R 67 (35-0)
1207	18952.421	2.420	R119 (38-0)
1208	18952.339	2.339	P 87 (36-0)
1209	18952.223	2.224	R106 (37-0)
1210	18952.115	2.116	P 23 (34-0)
1211	18951.937	1.937	R 26 (34-0)
1212	18951.649		
1213	18951.325	1.350	R139 (40-0)
		1.323	P 24 (34-0)
1214	18951.272	1.273	R130 (39-0)
		1.267	P117 (38-0)
1215	18951.141	1.147	P 65 (35-0)
		1.135	R 27 (34-0)
		1.095	P137 (40-0)
1216	18950.930	0.931	R 90 (36-0)
1217	18950.799	0.800	P104 (37-0)
		0.734	R159 (43-0)
1218	18950.499	0.517	P128 (39-0)
		0.497	P 25 (34-0)
1219	18950.379	0.379	R 68 (35-0)
1220	18950.302	0.302	R 28 (34-0)
1221	18949.883	9.885	P145 (41-0)
1222	18949.640	9.641	P 26 (34-0)
	18949.544	9.544	R147 (41-0)
1223	18949.427	9.438	R 29 (34-0)
		9.400	P 88 (36-0)
	18949.125		
1224	18948.987	8.986	P 66 (35-0)
	18948.875		
1225	18948.753	8.753	P 27 (34-0)
1226	18948.638	8.639	R107 (37-0)
1227	18948.543	8.543	R 30 (34-0)
1228	18948.283	8.284	R120 (38-0)
1229	18948.204	8.205	R 69 (35-0)
1230	18947.968	7.970	R 91 (36-0)
		7.907	P152 (42-0)
1231	18947.834	7.834	P 28 (34-0)
1232	18947.615	7.616	R 31 (34-0)
	18947.487		
	18947.389	7.390	P167 (45-0)
1233	18947.209	7.209	P105 (37-0)
1234	18947.130	7.131	P118 (38-0)
1235	18946.883	6.885	R154 (42-0)
		6.883	P 29 (34-0)
1236	18946.794	6.793	P 67 (35-0)
1237	18946.654	6.657	R 32 (34-0)
		6.628	R131 (39-0)
1238	18946.426	6.426	P 89 (36-0)
	18946.245	6.243	R140 (40-0)
1239	18945.997	6.002	P138 (40-0)
		5.997	R 70 (35-0)
1240	18945.897	5.901	P 30 (34-0)
		5.878	P129 (39-0)
1241	18945.667	5.667	R 33 (34-0)
	18945.344		
1242	18944.979	5.019	R108 (37-0)
		4.975	R 92 (36-0)
1243	18944.887	4.888	P 31 (34-0)
1244	18944.646	4.646	R 34 (34-0)
1245	18944.568	4.568	P 68 (35-0)
	10944.353	4.377	R160 (43-0)
		4.352	P146 (41-0)
1246	18944.110	4.110	R121 (38-0)
	18943.992	3.989	R148 (41-0)
1247	18943.843	3.843	P 32 (34-0)
1248	18943.757	3.757	R 71 (35-0)
1249	18943.590	3.593	R 35 (34-0)
		3.583	P106 (37-0)
1250	18943.418	3.419	P 90 (36-0)
	18943.166		
1251	18942.957	2.958	P119 (38-0)
1252	18942.766	2.767	P 33 (34-0)
1253	18942.509	2.509	R 36 (34-0)
1254	18942.310	2.310	P 69 (35-0)
1255	18941.943	1.950	P153 (42-0)
		1.946	R 93 (36-0)
		1.943	R132 (39-0)
1256	18941.659	1.659	P 34 (34-0)
1257	18941.485	1.484	R 72 (35-0)
1258	18941.386	1.394	R 37 (34-0)
		1.363	R109 (37-0)
1259	18941.197	1.201	P130 (39-0)
1260	18941.092	1.096	R141 (40-0)
1261	18940.870	0.897	R155 (42-0)
		0.870	P139 (40-0)
1262	18940.520	0.520	P 35 (34-0)
1263	18940.377	0.378	P 91 (36-0)
1264	18940.247	0.246	R 38 (34-0)
	18940.157		
1265	18940.019	0.019	P 70 (35-0)
1266	18939.915	9.921	P107 (37-0)
		9.899	R122 (38-0)
	18939.815		



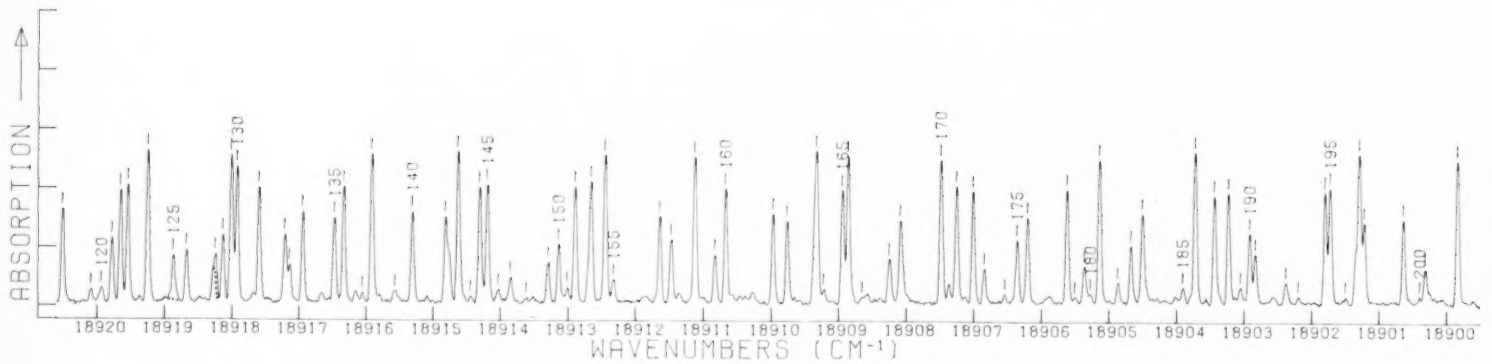
LINE	OBS CM-1	CALC	ASSIGNMENT
1262	18940.520	0.520	P 35 (34-0)
1263	18940.377	0.378	P 91 (36-0)
1264	18940.247	0.246	R 38 (34-0)
	18940.157		
1265	18940.019	0.019	P 70 (35-0)
1266	18939.915	9.921	P107 (37-0)
		9.899	R122 (38-0)
	18939.815		
1267	18939.349	9.350	P 36 (34-0)
1268	18939.178	9.178	R 73 (35-0)
1269	18939.067	9.068	R 39 (34-0)
1270	18938.883	8.883	R 94 (36-0)
1271	18938.752	8.778	P147 (41-0)
		8.748	P120 (38-0)
	18938.685		
	18938.393	8.391	R149 (41-0)
1272	18938.147	8.148	P 37 (34-0)
CALC	*********	7.972	R161 (43-0)
1273	18937.857	7.858	R 40 (34-0)
1274	18937.690	7.696	P 71 (35-0)
		7.672	R110 (37-0)
	18937.449		
1275	18937.302	7.303	P 92 (36-0)
1276	18937.217	7.219	R133 (39-0)
1277	18936.913	6.915	P 38 (34-0)
1278	18936.840	6.840	R 74 (35-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
1279	18936.615	6.616	R 41 (34-0)
1280	18936.480	6.485	P131 (39-0)
1281	18936.391		
1282	18936.225	6.224	P108 (37-0)
1283	18935.903	5.950	P154 (42-0)
		5.907	R142 (40-0)
1284	18935.784	5.785	R 95 (36-0)
1285	18935.650	5.697	P140 (40-0)
		5.652	R123 (38-0)
		5.650	P 39 (34-0)
1286	18935.341	5.343	R 42 (34-0)
		5.340	P 72 (35-0)
1287	18934.864	4.864	R156 (42-0)
	18934.729		
	18934.604		
1288	18934.471	4.501	P121 (38-0)
		4.468	R 75 (35-0)
1289	18934.354	4.354	P 40 (34-0)
1290	18934.192	4.194	P 93 (36-0)
1291	18934.037	4.038	R 43 (34-0)
1292	18933.945	3.945	R111 (37-0)
CALC	*********	3.161	P148 (41-0)
1293	18933.025	3.026	P 41 (34-0)
1294	18932.951	2.951	P 73 (35-0)
1295	18932.700	2.750	R150 (41-0)
		2.702	R 44 (34-0)

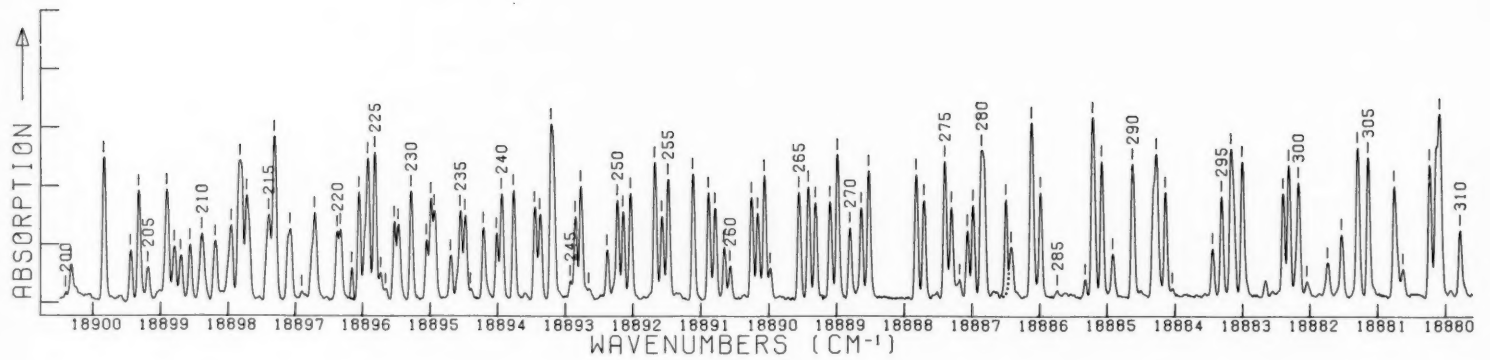
LINE	OBS CM-1	CALC	ASSIGNMENT
	18932.662	2.653	R 96 (36-0)
1296	18932.489	2.492	P109 (37-0)
		2.457	R134 (39-0)
1297	18932.065	2.064	R 76 (35-0)
1298	18931.668	1.731	P132 (39-0)
		1.667	P 42 (34-0)
		1.520	R162 (43-0)
1299	18931.336	1.366	R124 (38-0)
		1.334	R 45 (34-0)
1300	18931.050	1.051	P 94 (36-0)
1301	18930.675	0.678	R143 (40-0)
1302	18930.530	0.529	P 74 (35-0)
		0.483	P141 (40-0)
1303	18930.275	0.276	P 43 (34-0)
1304	18930.190	0.217	P122 (38-0)
		0.182	R112 (37-0)
1305	18929.933	9.934	R 46 (34-0)
		9.904	P155 (42-0)
1306	18929.627	9.627	R 77 (35-0)
1307	18929.487	9.487	R 97 (36-0)
	18929.283		
1308	18928.853	8.854	P 44 (34-0)
		8.786	R157 (42-0)
1309	18928.723	8.724	P110 (37-0)
1310	18928.503	8.503	R 47 (34-0)
	18928.302		

LINE	OBS CM-1	CALC	ASSIGNMENT
1311	18928.075	8.075	P 75 (35-0)
1312	18927.873	7.874	P 95 (36-0)
1313	18927.651	7.655	R135 (39-0)
	18927.502	7.502	P149 (41-0)
1314	18927.400	7.400	P 45 (34-0)
1315	18927.157	7.157	R 78 (35-0)
1316	18927.042	7.067	R151 (41-0)
		7.044	R125 (38-0)
		7.040	R 48 (34-0)
1317	18926.938	6.938	P133 (39-0)
1318	18926.835		
	18926.675		
1319	18926.382	6.384	R113 (37-0)
1320	18926.285	6.287	R 98 (36-0)
1321	18925.911	5.915	P 46 (34-0)
		5.896	P123 (38-0)
1322	18925.552	5.588	P 76 (35-0)
		5.546	R 49 (34-0)
1323	18925.410	5.408	R144 (40-0)
	18925.229	5.229	P142 (40-0)
	18925.186		
	18925.019	5.020	R163 (43-0)
1324	18924.920	4.920	P111 (37-0)
1325	18924.656	4.662	P 96 (36-0)
		4.654	R 79 (35-0)
1326	18924.398	4.398	P 47 (34-0)

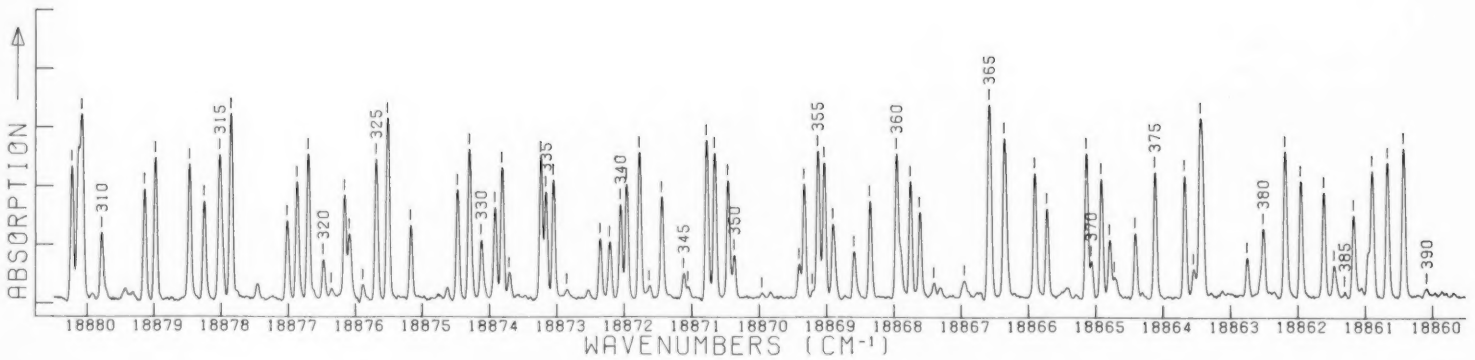
LINE	OBS CM-1	CALC	ASSIGNMENT
1327	18924.021	4.020	R 50 (34-0)
	18923.815	3.815	P156 (42-0)
	18923.310		
1328	18923.062	3.068	P 77 (35-0)
		3.052	R 99 (36-0)
1329	18922.848	2.850	P 48 (34-0)
		2.814	R136 (39-0)
1330	18922.683	2.684	R126 (38-0)
		2.664	R158 (42-0)
1331	18922.548	2.549	R114 (37-0)
1332	18922.463	2.462	R 51 (34-0)
1333	18922.116	2.116	R 80 (35-0)
		2.106	P134 (39-0)
	18921.820	1.800	P150 (41-0)
	18921.754		
1334	18921.538	1.537	P124 (38-0)
1335	18921.416	1.416	P 97 (36-0)
		1.340	R152 (41-0)
1336	18921.270	1.270	P 49 (34-0)
1337	18921.080	1.081	P112 (37-0)
1338	18920.873	0.873	R 52 (34-0)
1339	18920.516	0.515	P 78 (35-0)
1340	18920.093	0.096	R145 (40-0)
	18919.538	9.934	P143 (40-0)
1341	18919.783	9.783	R100 (36-0)
1342	18919.657	9.658	P 50 (34-0)
1343	18919.549	9.549	R 81 (35-0)



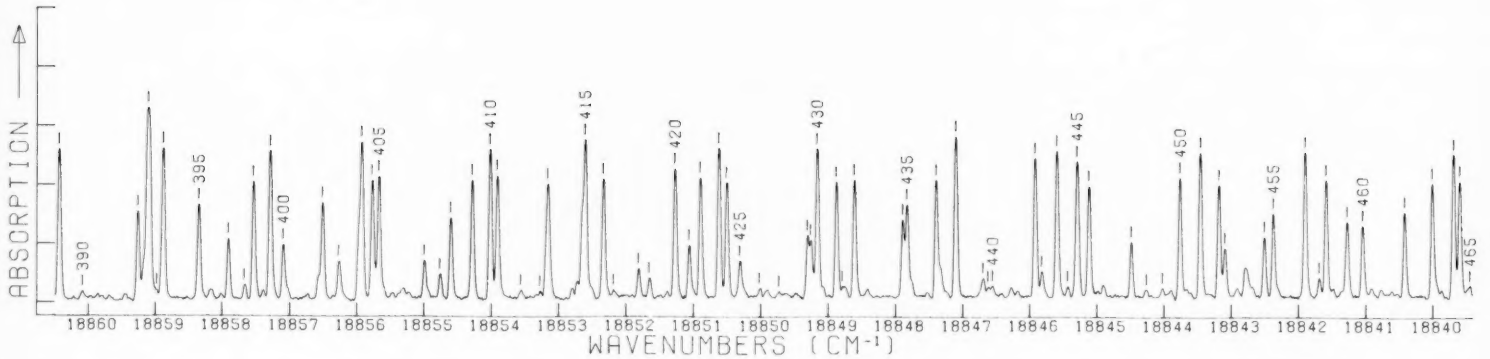
LINE	OBS CM-1	CALC	ASSIGNMENT
118	18920.513	0.515	P 7A (35-0)
119	18920.088	0.096	R145 (40-0)
120	18919.936	9.934	P143 (40-0)
121	18919.780	9.783	R100 (36-0)
122	18919.655	9.658	P 50 (34-0)
123	18919.546	9.549	R 81 (35-0)
	18919.363		
124	18919.249	9.252	R 53 (34-0)
125	18918.674	*****	ARTIFACT
126	18918.674	8.679	R115 (37-0)
	18918.286	8.286	R127 (38-0)
127	18918.245	*****	ARTIFACT
128	18918.135	8.136	P 98 (36-0)
129	18918.012	8.015	P 51 (34-0)
130	18917.927	7.934	R137 (39-0)
		7.929	P 79 (35-0)
	18917.688	7.680	P157 (42-0)
131	18917.598	7.599	R 54 (34-0)
132	18917.209	7.235	P135 (39-0)
		7.206	P113 (37-0)
133	18917.141	7.142	P125 (38-0)
134	18916.944	6.946	R 82 (35-0)
	18916.671		
135	18916.477	6.495	R159 (42-0)
		6.479	R101 (36-0)
136	18916.337	6.340	P 52 (34-0)
	18916.152		
137	18916.055	6.055	P151 (41-0)
138	18915.913	5.915	R 55 (34-0)
	18915.810		
139	18915.561	5.571	R153 (41-0)
140	18915.309	5.311	P 80 (35-0)
	18915.103		
141	18914.819	4.822	P 99 (36-0)
		4.772	R116 (37-0)
		4.744	R146 (40-0)
142	18914.631	4.633	P 53 (34-0)
		4.599	P144 (40-0)
143	18914.442		
144	18914.309	4.311	R 83 (35-0)
145	18914.196	4.198	R 56 (34-0)
146	18914.031		
147	18913.851	3.851	R128 (38-0)
148	18913.611		
149	18913.294	3.296	P114 (37-0)
150	18913.139	3.141	R102 (36-0)
151	18913.012	3.015	R138 (39-0)
152	18912.893	2.895	P 54 (34-0)
153	18912.658	2.709	P126 (38-0)
		2.659	P 81 (35-0)
154	18912.448	2.450	R 57 (34-0)
155	18912.327	2.326	P136 (39-0)
156	18911.642	1.643	R 84 (35-0)
157	18911.471	1.501	P158 (42-0)
		1.474	P100 (36-0)
	18911.359		
158	18911.122	1.125	P 55 (34-0)
159	18910.827	0.830	R117 (37-0)
160	18910.668	0.670	R 58 (34-0)
	18910.571		
	18910.469		
	18910.385		
	18910.275	0.282	R160 (42-0)
		0.268	P152 (41-0)
161	18909.973	9.974	P 82 (35-0)
162	18909.764	9.768	R103 (36-0)
		9.758	R154 (41-0)
163	18909.328	9.378	R129 (38-0)
		9.350	R147 (40-0)
		9.349	P115 (37-0)
		9.323	P 56 (34-0)
164	18909.221	9.223	P145 (40-0)
165	18908.942	8.941	R 85 (35-0)
166	18908.858	8.858	R 59 (34-0)
167	18908.648		
	18908.577		
	18908.392		
168	18908.250	*****	ARTIFACT
	18908.240	8.239	P127 (38-0)
169	18908.086	8.091	P101 (36-0)
		8.056	R139 (39-0)
170	18907.489	7.489	P 57 (34-0)
	18907.375	7.377	P137 (39-0)
171	18907.257	7.257	P 83 (35-0)
	18907.137		
172	18907.013	7.015	R 60 (34-0)
173	18906.847	6.851	R118 (37-0)
174	18906.539		
175	18906.360	6.361	R104 (36-0)
176	18906.207	6.206	R 86 (35-0)
177	18905.623	5.624	P 58 (34-0)
178	18905.509		
179	18905.365	5.367	P116 (37-0)
180	18905.271	5.277	P159 (42-0)
181	18905.138	5.139	R 61 (34-0)
182	18904.868	4.867	R130 (38-0)
183	18904.673	4.674	P102 (36-0)
184	18904.506	4.506	P 84 (35-0)
		4.438	P153 (41-0)
	18904.021	4.023	R161 (42-0)
185	18903.910	3.915	R14A (40-0)
		3.901	R155 (41-0)
	18903.805	3.806	P146 (40-0)
186	18903.727	3.732	P128 (38-0)
		3.727	P 59 (34-0)
187	18903.439	3.439	R 87 (35-0)
188	18903.232	3.232	R 62 (34-0)
189	18903.055	3.057	R140 (39-0)
190	18902.917	2.919	R105 (36-0)
191	18902.835	2.836	R119 (37-0)
	18902.560		
192	18902.381	2.389	P13A (39-0)
193	18902.198		
194	18901.799	1.798	P 60 (34-0)
195	18901.724	1.722	P 85 (35-0)
196	18901.499		
197	18901.292	1.349	P117 (37-0)
		1.293	R 63 (34-0)
198	18901.221	1.222	P103 (36-0)
199	18900.638	0.637	R 88 (35-0)
200	18900.400		
201	18900.319	0.319	R131 (38-0)
202	18899.836	9.838	P 61 (34-0)



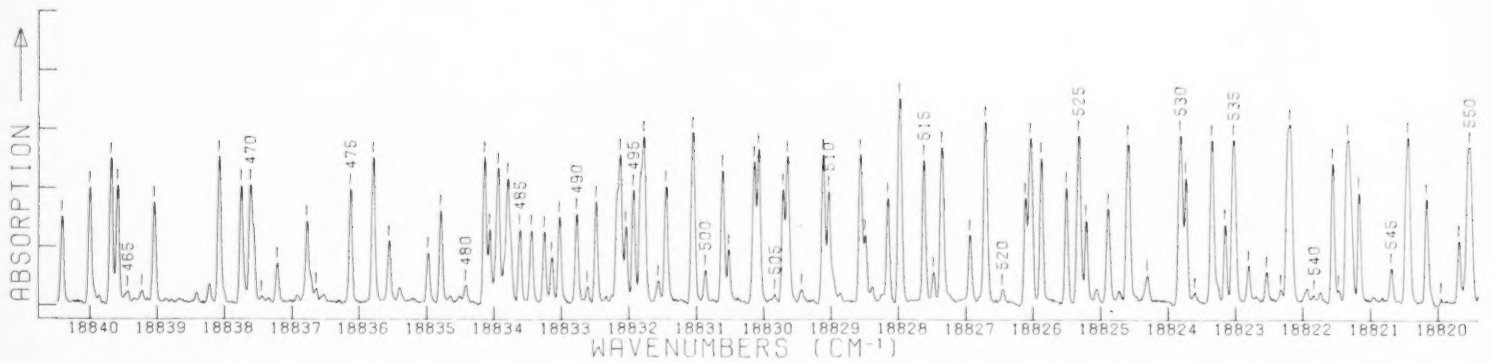
LINE	OBS CM-1	CALC	ASSIGNMENT
200	18900.400		
201	18900.319	0.319	R131 (38-0)
202	18899.836	9.838	P 61 (34-0)
203	18899.440	9.442	R106 (36-0)
204	18899.321	9.322	R 64 (34-0)
205	18899.186	9.186	P129 (38-0)
	18899.025	9.008	P160 (42-0)
206	18898.907	8.951	R 1 (33-0)
		8.938	R 0 (33-0)
		8.933	R 2 (33-0)
		8.906	P 86 (35-0)
		8.885	R 3 (33-0)
207	18898.792	8.819	P 1 (33-0)
		8.807	R 4 (33-0)
		8.785	R120 (37-0)
208	18898.698	8.716	P 2 (33-0)
		8.697	R 5 (33-0)
209	18898.561	8.578	P 3 (33-0)
		8.565	P154 (41-0)
		8.557	R 6 (33-0)
210	18898.387	8.438	R149 (40-0)
		8.411	P 4 (33-0)
		8.387	R 7 (33-0)
		8.348	P147 (40-0)
211	18898.191	8.214	P 5 (33-0)
		8.186	R 8 (33-0)
212	18897.959	8.019	R141 (39-0)
		8.001	R156 (41-0)
		7.986	P 6 (33-0)
		7.954	R 9 (33-0)
213	18897.824	7.845	P 62 (34-0)
		7.803	R 89 (35-0)
214	18897.727	7.736	P104 (36-0)
		7.728	P 7 (33-0)
		7.718	R162 (42-0)
		7.691	R 10 (33-0)
215	18897.398	7.438	P 8 (33-0)
		7.398	R 11 (33-0)
		7.361	P139 (39-0)
216	18897.316	7.319	R 65 (34-0)
		7.295	P118 (37-0)
217	18897.078	7.119	P 9 (33-0)
		7.074	R 12 (33-0)
218	18896.907		
219	18896.718	6.768	P 10 (33-0)
		6.719	R 13 (33-0)
220	18896.385	6.387	P 11 (33-0)
221	18896.336	6.334	R 14 (33-0)
222	18896.167	*****	ARTIFACT
223	18896.057	6.056	P 87 (35-0)
224	18895.923	5.975	P 12 (33-0)
		5.931	R107 (36-0)
		5.917	R 15 (33-0)
225	18895.821	5.821	P 63 (34-0)
226	18895.732	5.732	R132 (38-0)
227	18895.657		
228	18895.529	5.532	P 13 (33-0)
229	18895.469	5.471	R 16 (33-0)
230	18895.283	5.284	R 66 (34-0)
231	18895.057	5.059	P 14 (33-0)
232	18894.991	4.993	R 17 (33-0)
233	18894.939	4.935	R 90 (35-0)
234	18894.698	4.698	R121 (37-0)
235	18894.553	4.604	P130 (38-0)
		4.555	P 15 (33-0)
236	18894.483	4.485	R 18 (33-0)
237	18894.405		
238	18894.214	4.215	P105 (36-0)
239	18894.017	4.021	P 16 (33-0)
240	18893.945	3.946	R 19 (33-0)
241	18893.765	3.765	P 64 (34-0)
	18893.602		
242	18893.454	3.456	P 17 (33-0)
243	18893.377	3.377	R 20 (33-0)
244	18893.210	3.217	R 67 (34-0)
		3.204	P119 (37-0)
		3.172	P 88 (35-0)
245	18892.927	2.941	R142 (39-0)
		2.920	R150 (40-0)
246	18892.856	2.860	P 18 (33-0)
		2.848	P148 (40-0)
247	18892.774	2.776	R 21 (33-0)
248	18892.655	2.693	P161 (42-0)
		2.649	P155 (41-0)
249	18892.385	2.384	R108 (36-0)
		2.295	P140 (39-0)
250	18892.232	2.233	P 19 (33-0)
251	18892.145	2.145	R 22 (33-0)
252	18892.036	2.057	R157 (41-0)
		2.034	R 91 (35-0)
253	18891.677	1.677	P 65 (34-0)
254	18891.573	1.576	P 20 (33-0)
255	18891.482	1.483	R 23 (33-0)
	18891.365	1.367	R163 (42-0)
256	18891.116	1.117	R 68 (34-0)
		1.108	R133 (38-0)
257	18890.886	0.888	P 21 (33-0)
258	18890.789	0.791	R 24 (33-0)
259	18890.661	0.659	P106 (36-0)
260	18890.573	0.574	R122 (37-0)
261	18890.257	0.256	P 89 (35-0)
262	18890.167	0.169	P 22 (33-0)
263	18890.066	0.068	R 25 (33-0)
264	18889.981	9.983	P131 (38-0)
265	18889.558	9.557	P 66 (34-0)
266	18889.417	9.419	P 23 (33-0)
267	18889.313	9.314	R 26 (33-0)
268	18889.095	9.099	R 92 (35-0)
		9.078	P120 (37-0)
269	18888.987	8.986	R 69 (34-0)
270	18888.803	8.803	R109 (36-0)
271	18888.637	8.639	P 24 (33-0)
272	18888.527	8.529	R 27 (33-0)
273	18887.827	7.828	P 25 (33-0)
		7.823	R143 (39-0)
274	18887.713	7.713	R 28 (33-0)
275	18887.405	7.405	P 67 (34-0)
		7.359	R151 (40-0)
276	18887.307	7.308	P149 (40-0)
		7.307	P 90 (35-0)
277	18887.184	7.189	P141 (39-0)
278	18887.069	7.069	P107 (36-0)
279	18886.985	6.987	R 29 (33-0)
280	18886.856	6.867	R 29 (33-0)
		6.823	R 70 (34-0)
	18886.689	6.689	P156 (41-0)
281	18886.499	*****	ARTIFACT
282	18886.423	6.445	R134 (38-0)
		6.414	R123 (37-0)
	18886.334	6.333	P162 (42-0)
283	18886.121	6.131	R 93 (35-0)
		6.114	P 27 (33-0)
		6.070	R158 (41-0)
284	18885.990	5.990	R 30 (33-0)
285	18885.741		
286	18885.324	5.325	P132 (38-0)
287	18885.212	5.221	P 68 (34-0)
		5.211	P 28 (33-0)
		5.187	R110 (36-0)
288	18885.082	5.082	R 31 (33-0)
289	18884.917	4.970	R164 (42-0)
		4.916	P121 (37-0)
290	18884.628	4.628	R 71 (34-0)
291	18884.279	4.324	P 91 (35-0)
		4.277	P 29 (33-0)
292	18884.143	4.143	R 32 (33-0)
293	18884.041		
294	18883.445	3.445	P108 (36-0)
295	18883.312	3.312	P 30 (33-0)
296	18883.168	3.173	R 33 (33-0)
		3.130	R 94 (35-0)
297	18883.005	3.005	P 69 (34-0)
	18882.664	2.666	R144 (39-0)
298	18882.402	2.400	R 72 (34-0)
299	18882.317	2.317	P 31 (33-0)
300	18882.175	2.218	R124 (37-0)
		2.173	R 34 (33-0)
301	18882.049	2.043	P142 (39-0)
302	18881.741	1.757	R152 (40-0)
		1.745	R135 (38-0)
		1.726	P150 (40-0)
303	18881.537	1.536	R111 (36-0)
304	18881.297	1.308	P 92 (35-0)
		1.290	P 32 (33-0)
305	18881.141	1.142	R 35 (33-0)
306	18880.757	0.758	P 70 (34-0)
		0.717	P122 (37-0)
		0.687	P157 (41-0)
307	18880.628	0.629	P133 (38-0)
308	18880.233	0.233	P 33 (33-0)
309	18880.088	0.141	R 73 (34-0)
		0.095	R 95 (35-0)
		0.080	R 36 (33-0)
		0.038	R159 (41-0)
	18879.932	9.928	P163 (42-0)
310	18879.786	9.785	P109 (36-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
308	18880.233	0.233	P 33 (33-0)
309	18880.088	0.141	R 73 (34-0)
		0.095	R 95 (35-0)
		0.080	R 36 (33-0)
		0.038	R159 (41-0)
	18879.932	9.928	P163 (42-0)
310	18879.786	9.785	P109 (36-0)
	18879.432		
	18879.316		
311	18879.145	9.145	P 34 (33-0)
312	18878.986	8.987	R 37 (33-0)
313	18878.478	8.526	R165 (42-0)
		8.478	P 71 (34-0)
314	18878.259	8.258	P 93 (35-0)
315	18878.026	8.027	P 35 (33-0)
		7.985	R125 (37-0)
316	18877.857	7.863	R 38 (33-0)
		7.850	R112 (36-0)
		7.849	R 74 (34-0)
	18877.467	7.468	R145 (39-0)
317	18877.025	7.026	R 96 (35-0)
		7.006	R136 (38-0)
318	18876.875	6.877	P 36 (33-0)
		6.858	P143 (39-0)
319	18876.709	6.708	R 39 (33-0)
320	18876.484	6.482	P123 (37-0)
321	18876.365		
322	18876.167	6.166	P 72 (34-0)
		6.113	R153 (40-0)
		6.102	P151 (40-0)
323	18876.095	6.091	P110 (36-0)
324	18875.893	5.896	P134 (38-0)
325	18875.696	5.697	P 37 (33-0)
326	18875.524	5.525	R 75 (34-0)
		5.522	R 40 (33-0)
327	18875.177	5.175	P 94 (35-0)
	18874.638	4.640	P158 (41-0)
328	18874.485	4.486	P 38 (33-0)
329	18874.306	4.306	R 41 (33-0)
330	18874.130	4.129	R113 (36-0)
331	18873.927	3.963	R160 (41-0)
		3.924	R 97 (35-0)
332	18873.823	3.822	P 73 (34-0)
333	18873.716	3.715	R126 (37-0)
	18873.479	3.477	P164 (42-0)
334	18873.243	3.244	P 39 (33-0)
335	18873.170	3.169	R 76 (34-0)
336	18873.058	3.058	R 42 (33-0)
337	18872.857		
	18872.542		
338	18872.363	2.362	P111 (36-0)
339	18872.221	2.230	R146 (39-0)
		2.229	R137 (38-0)
		2.211	P124 (37-0)
340	18872.062	2.059	P 95 (35-0)
		2.037	R166 (42-0)
341	18871.971	1.971	P 40 (33-0)
342	18871.780	1.780	R 43 (33-0)
343	18871.632	1.633	P144 (39-0)
344	18871.447	1.446	P 74 (34-0)
345	18871.124	1.124	P135 (38-0)
346	18871.060		
347	18870.785	0.789	R 98 (35-0)
		0.781	R 77 (34-0)
348	18870.667	0.667	P 41 (33-0)
349	18870.470	0.470	R 44 (33-0)
		0.437	P152 (40-0)
		0.427	R154 (40-0)
350	18870.374	0.373	R114 (36-0)
351	18869.962		
	18869.841		
352	18869.411	9.409	R127 (37-0)
353	18869.333	9.332	P 42 (33-0)
354	18869.210		
355	18869.131	9.130	R 45 (33-0)
356	18869.039	9.038	P 75 (34-0)
357	18868.908	8.909	P 96 (35-0)
358	18868.598	8.598	P112 (36-0)
		8.550	P159 (41-0)
359	18868.361	8.360	R 78 (34-0)
360	18867.967	7.966	P 43 (33-0)
	18867.912	7.903	P125 (37-0)
		7.843	R161 (41-0)
361	18867.759	7.759	R 46 (33-0)
362	18867.620	7.619	R 99 (35-0)
363	18867.408	7.413	R138 (38-0)
	18867.319		
364	18866.956	6.980	P165 (42-0)
		6.952	R147 (39-0)
365	18866.583	6.597	P 76 (34-0)
		6.582	R115 (36-0)
		6.570	P 44 (33-0)
366	18866.357	6.369	P145 (39-0)
		6.356	R 47 (33-0)
		6.314	P136 (38-0)
367	18865.908	5.907	R 79 (34-0)
368	18865.729	5.726	P 97 (35-0)
	18865.424	5.500	R167 (42-0)
369	18865.143	5.142	P 45 (33-0)
370	18865.070	5.065	R128 (37-0)
371	18864.923	4.923	R 48 (33-0)
372	18864.800	4.800	P113 (36-0)
373	18864.727	4.730	P153 (40-0)
		4.699	R155 (40-0)
374	18864.417	4.416	R100 (35-0)
375	18864.126	4.125	P 77 (34-0)
376	18863.685	3.684	P 46 (33-0)
377	18863.555	3.559	P126 (37-0)
378	18863.449	3.458	R 49 (33-0)
		3.422	R 80 (34-0)
379	18862.756	2.756	R116 (36-0)
380	18862.513	2.559	R139 (38-0)
		2.510	P 98 (35-0)
	18862.418	2.417	P160 (41-0)
381	18862.195	2.195	P 47 (33-0)
382	18861.964	1.963	R 50 (33-0)
383	18861.622	1.679	R162 (41-0)
		1.634	R148 (39-0)
		1.620	P 78 (34-0)
384	18861.468	1.466	P137 (38-0)
385	18861.313		
386	18861.181	1.179	R101 (35-0)
	18861.065	1.064	P146 (39-0)
387	18860.905	0.966	P114 (36-0)
		0.904	R 81 (34-0)
388	18860.676	0.686	R129 (37-0)
		0.674	P 48 (33-0)
389	18860.438	0.437	R 51 (33-0)
		0.436	P166 (42-0)
390	18860.092		



LINE	OBS CM-1	CALC	ASSIGNMENT
389	18860.438	0.437	R 51 (33-0)
		0.436	P166 (42-0)
390	18860.092		
391	18859.260	9.259	P 99 (35-0)
392	18859.107	9.179	P127 (37-0)
		9.123	P 49 (33-0)
		9.083	P 79 (34-0)
393	18858.981	8.982	P154 (40-0)
394	18858.884	8.928	R156 (40-0)
		8.917	R168 (42-0)
		8.894	R117 (36-0)
		8.879	R 52 (33-0)
395	18858.355	8.354	R 82 (34-0)
	18858.175		
	18858.022		
396	18857.910	7.909	R102 (35-0)
397	18857.672	7.667	R140 (38-0)
398	18857.541	7.541	P 50 (33-0)
	18857.397		
399	18857.292	7.290	R 53 (33-0)
400	18857.099	7.097	P115 (36-0)
	18856.577	6.580	P138 (38-0)
401	18856.515	6.514	P 80 (34-0)
402	18856.271	6.275	R149 (39-0)
		6.269	R130 (37-0)
		6.239	P161 (41-0)
403	18855.930	5.975	P100 (35-0)
		5.927	P 51 (33-0)
404	18855.773	5.772	R 83 (34-0)
		5.720	P147 (39-0)
405	18855.674	5.671	R 54 (33-0)
	18855.473	5.470	R163 (41-0)
	18855.309		
	18855.222		
406	18854.998	4.997	R118 (36-0)
407	18854.765	4.762	P128 (37-0)
408	18854.606	4.604	R103 (35-0)
409	18854.285	4.283	P 52 (33-0)
410	18854.022	4.020	R 55 (33-0)
411	18853.913	3.912	P 81 (34-0)
		3.847	P167 (42-0)
412	18853.568		
413	18853.278		
414	18853.163	3.193	P116 (36-0)
		3.191	P155 (40-0)
		3.157	R 84 (34-0)
		3.115	R157 (40-0)
	18852.806		
	18852.734	2.735	R141 (38-0)
415	18852.610	2.658	P101 (35-0)
		2.607	P 53 (33-0)
416	18852.338	2.338	R 56 (33-0)
		2.287	R169 (42-0)
417	18852.186		
418	18851.815	1.815	R131 (37-0)
419	18851.657	1.656	P139 (38-0)
	18851.392		
420	18851.276	1.278	P 82 (34-0)
		1.266	R104 (35-0)
421	18851.067	1.065	R119 (36-0)
422	18850.900	0.901	P 54 (33-0)
		0.876	R150 (39-0)
423	18850.626	0.624	R 57 (33-0)
424	18850.510	0.510	R 85 (34-0)
425	18850.313	0.335	P148 (39-0)
		0.308	P129 (37-0)
426	18850.021	0.017	P162 (41-0)
	18849.919		
427	18849.730		
428	18849.306	9.307	P102 (35-0)
429	18849.258	9.254	P117 (36-0)
		9.216	R164 (41-0)
430	18849.164	9.163	P 55 (33-0)
431	18848.883	8.880	R 58 (33-0)
432	18848.794		
433	18848.614	8.612	P 83 (34-0)
	18848.427		
434	18847.894	7.894	R105 (35-0)
435	18847.832	7.830	R 86 (34-0)
	18847.767	7.765	R142 (38-0)
436	18847.396	7.395	P 56 (33-0)
		7.358	P156 (40-0)
	18847.337	7.324	R132 (37-0)
	18847.261	7.259	R158 (40-0)
		7.211	P168 (42-0)
437	18847.105	7.105	R 59 (33-0)
		7.097	R120 (36-0)
438	18846.694	6.693	P140 (38-0)
439	18846.622		
440	18846.552		
	18846.277		
	18846.184		
441	18845.920	5.922	P103 (35-0)
		5.914	P 84 (34-0)
442	18845.822	5.817	P130 (37-0)
443	18845.596	5.610	R170 (42-0)
		5.595	P 57 (33-0)
444	18845.435	5.436	R151 (39-0)
445	18845.297	5.298	R 60 (33-0)
		5.280	P118 (36-0)
446	18845.118	5.117	R 87 (34-0)
	18844.909	4.910	P149 (39-0)
447	18844.490	4.488	R106 (35-0)
448	18844.260		
449	18844.026		
450	18843.765	3.764	P 58 (33-0)
		3.752	P163 (41-0)
451	18843.462	3.460	R 61 (33-0)
452	18843.185	3.183	P 85 (34-0)
453	18843.097	3.094	R121 (36-0)
	18842.915	2.918	R165 (41-0)
	18842.776	2.796	R133 (37-0)
		2.757	R143 (38-0)
454	18842.504	2.503	P104 (35-0)
455	18842.372	2.373	R 88 (34-0)
456	18841.904	1.902	P 59 (33-0)
457	18841.692	1.692	P141 (38-0)
458	18841.592	1.590	R 62 (33-0)
	18841.486	1.483	P157 (40-0)
	18841.361	1.361	R159 (40-0)
459	18841.279	1.290	P131 (37-0)
		1.271	P119 (36-0)
460	18841.049	1.048	R107 (35-0)
	18840.917		
	18840.773		
	18840.695		
	18840.615		
	18840.534	0.529	P169 (42-0)
461	18840.421	0.419	P 86 (34-0)
462	18840.010	0.009	P 60 (33-0)
		9.955	R152 (39-0)
	18839.877		
463	18839.692	9.690	R 63 (33-0)
464	18839.596	9.595	R 89 (34-0)
465	18839.447	9.445	P150 (39-0)



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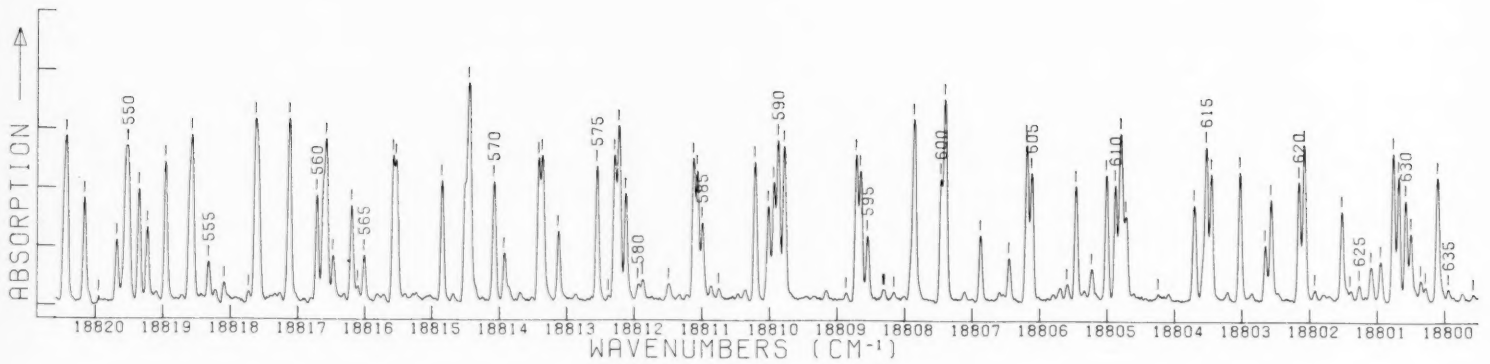
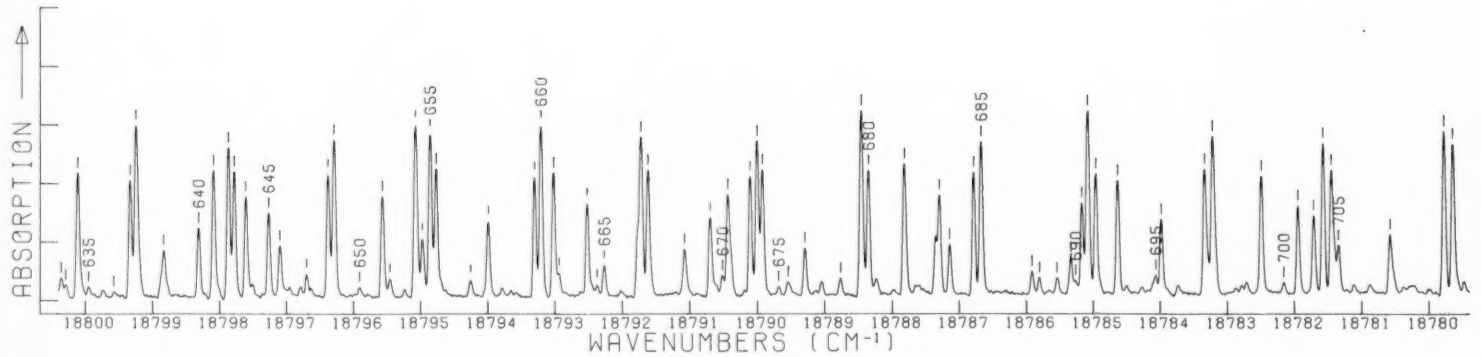
461	18840.421	0.419	P A6 (34-0)
462	18840.010	0.009	P 60 (33-0)
		9.955	R152 (39-0)
	18839.877		
463	18839.692	9.690	R 63 (33-0)
464	18839.596	9.595	R A9 (34-0)
465	18839.447	9.445	P150 (39-0)
466	18839.232		
467	18839.054	9.055	R122 (36-0)
		9.051	P105 (35-0)
	18838.881	8.886	R171 (42-0)
	18838.421		
	18838.232	8.231	R134 (37-0)
468	18838.085	8.084	P 61 (33-0)
469	18837.760	7.758	R 64 (33-0)
		7.709	R144 (38-0)
470	18837.624	7.624	P A7 (34-0)
		7.573	R108 (35-0)
471	18837.455	7.441	P164 (41-0)
472	18837.224	7.226	P120 (36-0)
	18836.930		
473	18836.784	6.785	R 90 (34-0)
	18836.732	6.726	P132 (37-0)
474	18836.646	6.652	P142 (38-0)
CALC	**********	6.575	R166 (41-0)
	18836.531		
475	18836.130	6.128	P 62 (33-0)
476	18835.796	5.795	R 65 (33-0)
477	18835.565	5.566	P158 (40-0)
		5.564	P106 (35-0)
	18835.410	5.419	R160 (40-0)
478	18834.985	4.981	R123 (36-0)
479	18834.797	4.795	P A8 (34-0)
480	18834.424	4.434	R153 (39-0)
481	18834.144	4.142	P 63 (33-0)
482	18834.068	4.065	R109 (35-0)
		4.001	R 1 (32-0)
483	18833.943	3.987	R 0 (32-0)
		3.986	R 2 (32-0)
		3.942	R 91 (34-0)
		3.940	R 3 (32-0)
		3.940	P151 (39-0)
484	18833.802	3.868	P 1 (32-0)
		3.864	R 4 (32-0)
		3.800	R 66 (33-0)
		3.800	P170 (42-0)
		3.763	P 2 (32-0)
		3.759	R 5 (32-0)
485	18833.623	3.629	R135 (37-0)
		3.628	P 3 (32-0)
		3.623	R 6 (32-0)
486	18833.452	3.464	P 4 (32-0)
		3.457	R 7 (32-0)
487	18833.259	3.269	P 5 (32-0)
		3.260	R A (32-0)
488	18833.147	3.146	P121 (36-0)
489	18833.031	3.044	P 6 (32-0)
		3.034	R 9 (32-0)
490	18832.778	2.788	P 7 (32-0)
		2.778	R 10 (32-0)
491	18832.620	2.622	R145 (38-0)
492	18832.491	2.503	P 8 (32-0)
		2.492	R 11 (32-0)
493	18832.129	2.188	P 9 (32-0)
		2.175	R 12 (32-0)
		2.125	P133 (37-0)
		2.124	P 64 (33-0)
		2.114	R172 (42-0)
494	18832.047	2.044	P107 (35-0)
495	18831.937	1.935	P A9 (34-0)
496	18831.780	1.843	P 10 (32-0)
		1.828	R 13 (32-0)
		1.775	R 67 (33-0)
497	18831.569	1.574	P143 (38-0)
498	18831.454	1.467	P 11 (32-0)
		1.452	R 14 (32-0)
499	18831.055	1.087	P165 (41-0)
		1.066	R 92 (34-0)
		1.062	P 12 (32-0)
		1.045	R 15 (32-0)
500	18830.874	0.871	R124 (36-0)
501	18830.613	0.626	P 13 (32-0)
		0.608	R 16 (32-0)
502	18830.525	0.523	R110 (35-0)
503	18830.144	0.186	R167 (41-0)
		0.160	P 14 (32-0)
		0.141	R 17 (32-0)
504	18830.077	0.074	P 65 (33-0)
505	18829.842		
506	18829.720	9.717	R 68 (33-0)
507	18829.651	9.665	P 15 (32-0)
		9.644	R 18 (32-0)
		9.607	P159 (40-0)
508	18829.445	9.435	R161 (40-0)
509	18829.120	9.139	P 16 (32-0)
		9.116	R 19 (32-0)
510	18829.039	9.041	P 90 (34-0)
		9.031	P122 (36-0)
		8.949	R136 (37-0)
	18828.872	8.871	R154 (39-0)
511	18828.567	8.583	P 17 (32-0)
		8.559	R 20 (32-0)
512	18828.497	8.490	P108 (35-0)
	18828.396	8.394	P152 (39-0)
513	18828.160	8.158	R 93 (34-0)
514	18827.983	7.996	P 18 (32-0)
		7.994	P 66 (33-0)
		7.971	R 21 (32-0)
515	18827.630	7.629	R 69 (33-0)
516	18827.488	7.496	R146 (38-0)
		7.487	P134 (37-0)
517	18827.362	7.380	P 19 (32-0)
		7.354	R 22 (32-0)
518	18826.947	7.024	P171 (42-0)
		6.946	R111 (35-0)
519	18826.714	6.734	P 20 (32-0)
		6.725	R125 (36-0)
		6.706	R 23 (32-0)
520	18826.459	6.457	P144 (38-0)
521	18826.116	6.115	P 91 (34-0)
522	18826.039	6.057	P 21 (32-0)
		6.028	R 24 (32-0)
523	18825.883	5.882	P 67 (33-0)
524	18825.512	5.509	R 70 (33-0)
525	18825.325	5.351	P 22 (32-0)
		5.319	R 25 (32-0)
		5.294	R173 (42-0)
526	18825.217	5.217	R 94 (34-0)
	18825.066		
527	18824.895	4.902	P109 (35-0)
		4.880	P123 (36-0)
	18824.731		
CALC	**********	4.687	P166 (41-0)
528	18824.594	4.614	P 23 (32-0)
		4.581	R 26 (32-0)
529	18824.312	4.312	R137 (37-0)
530	18823.819	3.847	P 24 (32-0)
		3.812	R 27 (32-0)
531	18823.740	3.753	R168 (41-0)
		3.738	P 68 (33-0)
532	18823.605	3.604	P160 (40-0)
533	18823.355	3.407	R162 (40-0)
		3.357	R 71 (33-0)
		3.335	R112 (35-0)
	18823.277	3.267	R155 (39-0)
534	18823.158	3.157	P 92 (34-0)
535	18823.029	3.050	P 25 (32-0)
		3.014	R 28 (32-0)
536	18822.811	2.812	P135 (37-0)
		2.807	P153 (39-0)
537	18822.542	2.544	R126 (36-0)
538	18822.330	2.331	R147 (38-0)
539	18822.193	2.243	R 95 (34-0)
		2.223	P 26 (32-0)
		2.185	R 29 (32-0)
	18821.950		
540	18821.839		
	18821.750		
541	18821.566	1.564	P 69 (33-0)
542	18821.475		
543	18821.336	1.365	P 27 (32-0)
		1.325	R 30 (32-0)
		1.301	P145 (38-0)
		1.280	P110 (35-0)
544	18821.177	1.174	R 72 (33-0)
545	18820.694	0.694	P124 (36-0)
546	18820.440	0.478	P 28 (32-0)
		0.436	R 31 (32-0)
547	18820.168	0.201	P172 (42-0)
		0.165	P 93 (34-0)
548	18819.954		
549	18819.692	9.690	R113 (35-0)
550	18819.527	9.598	R138 (37-0)
		9.560	P 29 (32-0)
		9.516	R 32 (32-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
546	18820.440	0.478	P 28 (32-0)
		0.436	R 31 (32-0)
547	18820.168	0.201	P172 (42-0)
		0.165	P 93 (34-0)
548	18819.954		
549	18819.692	9.690	R113 (35-0)
550	18819.527	9.598	R138 (37-0)
		9.560	P 29 (32-0)
		9.516	R 32 (32-0)
551	18819.358	9.358	P 70 (33-0)
552	18819.235	9.236	R 96 (34-0)
	18819.105		
553	18818.961	8.960	R 73 (33-0)
554	18818.570	8.612	P 30 (32-0)
		8.566	R 33 (32-0)
	18818.429	8.427	R174 (42-0)
555	18818.327	8.326	R127 (36-0)
	18818.228	8.243	P167 (41-0)
556	18818.093	8.100	P136 (37-0)
557	18817.729		
558	18817.624	7.634	P 31 (32-0)
		7.623	P111 (35-0)
		7.622	R156 (39-0)
		7.586	R 34 (32-0)
		7.560	P161 (40-0)
	18817.339	7.337	R163 (40-0)
	18817.273	7.273	R169 (41-0)
559	18817.128	7.180	P154 (39-0)
		7.141	P 94 (34-0)
		7.127	R148 (38-0)
		7.120	P 71 (33-0)
560	18816.715	6.714	R 74 (33-0)
561	18816.576	6.625	P 32 (32-0)
		6.576	R 35 (32-0)
562	18816.472	6.472	P125 (36-0)
	18816.313		
563	18816.197	6.196	R 97 (34-0)
564	18816.108	6.106	P146 (38-0)
565	18816.012	6.010	R114 (35-0)
	18815.818		
	18815.732		
566	18815.581	5.587	P 33 (32-0)
567	18815.540	5.535	R 36 (32-0)
568	18814.852	4.852	P 72 (33-0)
		4.846	R139 (37-0)
	18814.690		
569	18814.451	4.518	P 34 (32-0)
		4.464	R 37 (32-0)
		4.436	R 75 (33-0)
570	18814.083	4.065	P 95 (34-0)
		4.073	R128 (36-0)
571	18813.934	3.933	P112 (35-0)
	18813.877		
	18813.704		
572	18813.416	3.419	P 35 (32-0)
573	18813.364	3.363	R 38 (32-0)
		3.350	P147 (37-0)
		3.331	P173 (42-0)
574	18813.125	3.124	R 98 (34-0)
	18812.877		
575	18812.552	2.551	P 73 (33-0)
576	18812.383		
577	18812.290	2.297	R115 (35-0)
		2.290	P 36 (32-0)
578	18812.230	2.232	R 39 (32-0)
		2.214	P126 (36-0)
579	18812.129	2.127	R 76 (33-0)
580	18811.945	1.936	R157 (39-0)
581	18811.879	1.883	R149 (38-0)
	18811.754	1.754	P168 (41-0)
582	18811.493	1.512	P155 (39-0)
		1.472	P162 (40-0)
	18811.343		
	18811.228	1.222	R164 (40-0)
583	18811.127	1.130	P 37 (32-0)
584	18811.071	1.070	R 40 (32-0)
585	18810.996	0.995	P 96 (34-0)
	18810.872	0.872	P147 (38-0)
586	18810.753	0.749	R170 (41-0)
	18810.366		
587	18810.217	0.220	P 74 (33-0)
		0.209	P113 (35-0)
588	18810.019	0.056	R140 (37-0)
		0.018	R 99 (34-0)
589	18809.938	9.941	P 38 (32-0)
590	18809.876	9.878	R 41 (32-0)
591	18809.787	9.786	R 77 (33-0)
		9.784	R129 (36-0)
	18809.171		
592	18808.867		
593	18808.718	8.721	P 39 (32-0)
594	18808.656	8.655	R 42 (32-0)
595	18808.554	8.563	P138 (37-0)
		8.548	R116 (35-0)
596	18808.319		
597	18808.301		
598	18808.159		
599	18807.865	7.921	P127 (36-0)
		7.873	P 97 (34-0)
		7.856	P 75 (33-0)
600	18807.465	7.470	P 40 (32-0)
601	18807.407	7.414	R 78 (33-0)
		7.402	R 43 (32-0)
602	18806.880	6.880	R100 (34-0)
	18806.596	6.600	R150 (38-0)
603	18806.452	6.450	P114 (35-0)
		6.413	P174 (42-0)
604	18806.189	6.208	R158 (39-0)
		6.190	P 41 (32-0)
605	18806.119	6.119	R 44 (32-0)
	18805.804	5.803	P156 (39-0)
	18805.703		
606	18805.594	5.600	P148 (38-0)
607	18805.463	5.462	P 76 (33-0)
		5.459	R130 (36-0)
	18805.339	5.341	P163 (40-0)
608	18805.230	5.229	R141 (37-0)
		5.220	P169 (41-0)
609	18805.011	5.065	R165 (40-0)
		5.010	R 79 (33-0)
610	18804.878	4.879	P 42 (32-0)
611	18804.801	4.806	R 45 (32-0)
		4.766	R117 (35-0)
612	18804.721	4.718	P 98 (34-0)
613	18804.246		
	18804.179	4.178	R171 (41-0)
	18804.096		
614	18803.711	3.739	P139 (37-0)
		3.708	R101 (34-0)
615	18803.537	3.592	P128 (36-0)
		3.538	P 43 (32-0)
616	18803.461	3.462	R 46 (32-0)
	18803.226		
617	18803.036	3.036	P 77 (33-0)
	18802.864		
618	18802.659	2.657	P115 (35-0)
619	18802.576	2.574	R 80 (33-0)
	18802.469		
620	18802.165	2.166	P 44 (32-0)
621	18802.087	2.087	R 47 (32-0)
622	18801.926		
	18801.808		
	18801.721		
623	18801.530	1.530	P 99 (34-0)
624	18801.405		
625	18801.271	1.277	R151 (38-0)
626	18801.094	1.097	R131 (36-0)
627	18800.949	0.948	R118 (35-0)
628	18800.763	0.764	P 45 (32-0)
629	18800.682	0.683	R 48 (32-0)
630	18800.579	0.578	P 78 (33-0)
631	18800.502	0.504	R102 (34-0)
		0.439	R159 (39-0)
632	18800.356	0.364	R142 (37-0)
633	18800.286	0.288	P149 (38-0)
634	18800.108	0.107	R 81 (33-0)
		0.052	P157 (39-0)
635	18799.950		
	18799.737		
636	18799.577		



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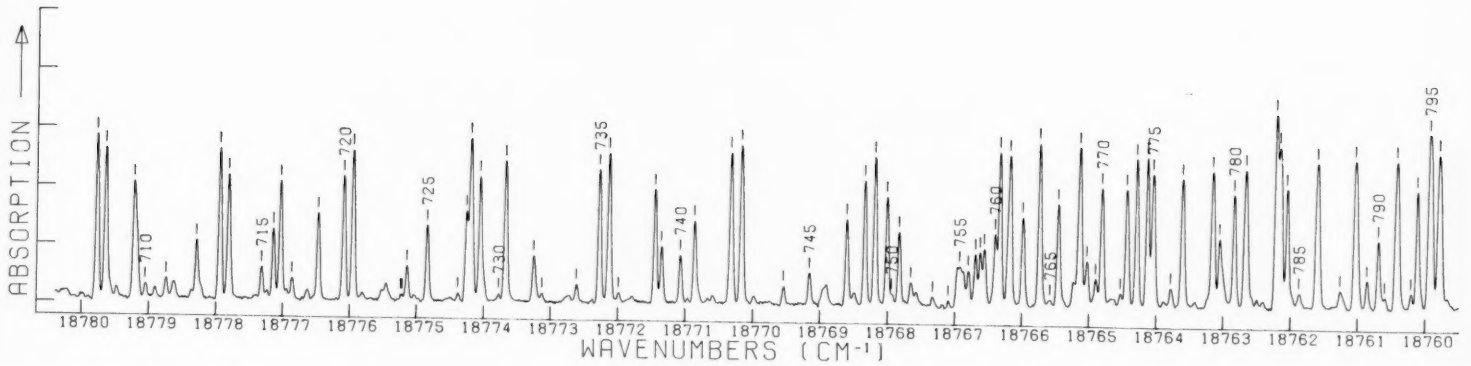
632	18800.356	0.364	R142 (37-0)
633	18800.286	0.288	P149 (38-0)
634	18800.108	0.107	R 81 (33-0)
		0.052	P157 (39-0)
635	18799.950		
	18799.737		
636	18799.577		
	18799.442	9.447	P175 (42-0)
637	18799.332	9.332	P 46 (32-0)
638	18799.244	9.247	R 49 (32-0)
		9.227	P129 (36-0)
		9.167	P164 (40-0)
639	18798.832	8.878	P140 (37-0)
		8.863	R166 (40-0)
		8.830	P116 (35-0)
	18798.638	8.640	P170 (41-0)
640	18798.310	8.310	P100 (34-0)
641	18798.089	8.088	P 79 (33-0)
	18798.017		
642	18797.868	7.869	P 47 (32-0)
643	18797.782	7.782	R 50 (32-0)
644	18797.608	7.608	R 82 (33-0)
		7.561	R172 (41-0)
	18797.513		
645	18797.267	7.266	R103 (34-0)
646	18797.098	7.097	R119 (35-0)
	18796.961		

LINE	OBS CM-1	CALC	ASSIGNMENT
	18796.796		
647	18796.699	6.700	R132 (36-0)
	18796.635		
648	18796.375	6.377	P 48 (32-0)
649	18796.286	6.286	R 51 (32-0)
650	18795.908	5.915	R152 (38-0)
651	18795.568	5.568	P 80 (33-0)
652	18795.455	5.461	R143 (37-0)
	18795.241		
653	18795.070	5.077	R 83 (33-0)
		5.056	P101 (34-0)
654	18794.968	4.968	P117 (35-0)
		4.936	P150 (38-0)
655	18794.851	4.853	P 49 (32-0)
		4.827	P130 (36-0)
656	18794.761	4.759	R 52 (32-0)
	18794.631	4.628	R160 (39-0)
657	18794.253	4.261	P158 (39-0)
658	18793.990	3.995	R104 (34-0)
		3.979	P141 (37-0)
	18793.789		
	18793.662		
659	18793.301	3.299	P 50 (32-0)
660	18793.205	3.210	R120 (35-0)
		3.202	R 53 (32-0)
661	18793.017	3.015	P 81 (33-0)
662	18792.938	2.950	P165 (40-0)
	18792.618	2.618	R167 (40-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
663	18792.514	2.514	R 84 (33-0)
664	18792.371		
665	18792.266	2.266	R133 (36-0)
	18792.015	2.016	P171 (41-0)
666	18791.717	1.769	P102 (34-0)
		1.715	P 51 (32-0)
667	18791.615	1.615	R 54 (32-0)
668	18791.072	1.072	P118 (35-0)
	18790.894	0.899	R173 (41-0)
669	18790.691	0.691	R105 (34-0)
	18790.608		
670	18790.511	0.520	R144 (37-0)
		0.512	R153 (38-0)
671	18790.431	0.431	P 82 (33-0)
		0.390	P131 (36-0)
	18790.186		
672	18790.101	0.101	P 52 (32-0)
673	18789.998	9.997	R 55 (32-0)
674	18789.920	9.920	R 85 (33-0)
675	18789.683		
676	18789.540	9.546	P151 (38-0)
677	18789.289	9.289	R121 (35-0)
	18789.044	9.042	P142 (37-0)
678	18788.760	8.775	R161 (39-0)
679	18788.453	8.456	P 53 (32-0)
		8.450	P103 (34-0)
		8.428	P159 (39-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
680	18788.348	8.348	R 56 (32-0)
	18788.240		
681	18787.814	7.815	P 83 (33-0)
		7.796	R134 (36-0)
682	18787.295	7.354	R106 (34-0)
		7.293	R 86 (33-0)
683	18787.141	7.141	P119 (35-0)
684	18786.781	6.780	P 54 (32-0)
685	18786.671	6.690	P166 (40-0)
		6.669	R 57 (32-0)
	18786.328	6.328	R168 (40-0)
686	18785.915	5.918	P132 (36-0)
687	18785.803		
688	18785.542	5.541	R145 (37-0)
689	18785.333	5.333	R122 (35-0)
690	18785.263		
691	18785.170	5.167	P 84 (33-0)
692	18785.080	5.097	P104 (34-0)
		5.074	P 55 (32-0)
		5.070	R154 (38-0)
693	18784.960	4.959	R 58 (32-0)
694	18784.635	4.635	R 87 (33-0)
	18784.512		
	18784.280		
695	18784.065	4.115	P152 (38-0)
		4.068	P143 (37-0)
696	18783.982	3.983	R107 (34-0)
	18783.739		

LINE	OBS CM-1	CALC	ASSIGNMENT
697	18783.338	3.338	P 56 (32-0)
		3.290	R135 (36-0)
698	18783.218	3.219	R 59 (32-0)
		3.176	P120 (35-0)
	18782.881	2.880	R162 (39-0)
	18782.791		
	18782.718		
699	18782.490	2.554	P160 (39-0)
		2.488	P 85 (33-0)
700	18782.158		
701	18781.945	1.945	R 88 (33-0)
702	18781.711	1.711	P105 (34-0)
703	18781.572	1.571	P 57 (32-0)
704	18781.449	1.448	R 60 (32-0)
		1.409	P133 (36-0)
705	18781.344	1.342	R123 (35-0)
	18781.119		
	18780.884		
706	18780.574	0.579	R108 (34-0)
		0.523	R146 (37-0)
	18780.384	0.386	P167 (40-0)
	18779.996	9.995	R169 (40-0)
707	18779.776	9.777	P 86 (33-0)
		9.773	P 58 (32-0)
708	18779.648	9.647	R 61 (32-0)
	18779.592	9.588	R155 (38-0)
	18779.487		



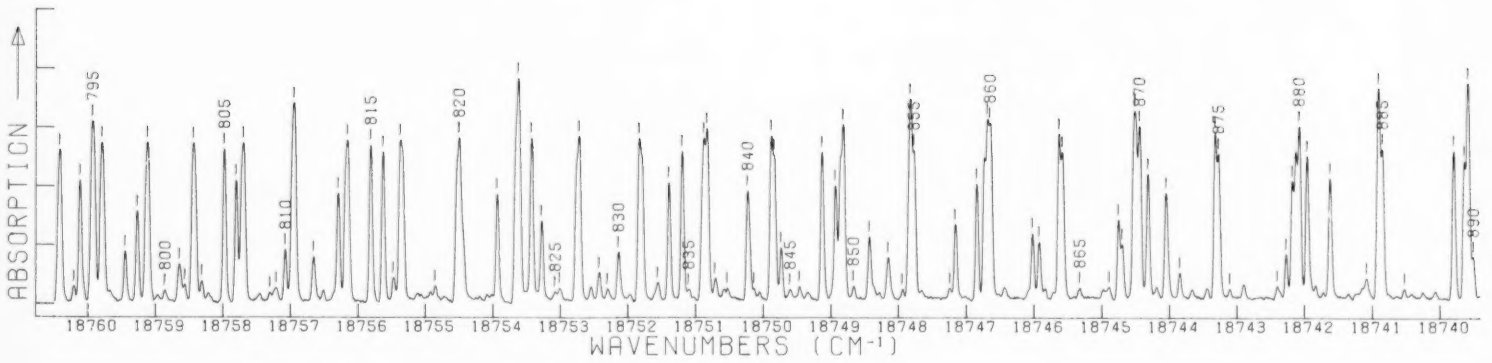
LINE	OBS CM-1	CALC	ASSIGNMENT
	18779.996	9.995	R169 (40-0)
707	18779.776	9.777	P 86 (33-0)
		9.773	P 58 (32-0)
708	18779.648	9.647	R 61 (32-0)
	18779.592	9.588	R155 (38-0)
	18779.487		
709	18779.221	9.223	R 89 (33-0)
		9.177	P121 (35-0)
710	18779.055	9.056	P144 (37-0)
	18778.914		
711	18778.744	8.747	R136 (36-0)
	18778.633	8.646	P153 (38-0)
	18778.372		
712	18778.292	8.292	P106 (34-0)
	18778.241		
713	18777.946	7.945	P 59 (32-0)
714	18777.815	7.815	R 62 (32-0)
715	18777.317	7.317	R124 (35-0)
	18777.239		
716	18777.142	7.142	R109 (34-0)
717	18777.035	7.034	P 87 (33-0)
	18776.944	6.943	R163 (39-0)
718	18776.863	6.864	P134 (36-0)
	18776.639	6.639	P161 (39-0)
719	18776.470	6.469	R 90 (33-0)
720	18776.090	6.087	P 60 (32-0)
721	18775.954	5.952	R 63 (32-0)
	18775.818		
	18775.468	5.468	R147 (37-0)
722	18775.233		
723	18775.213		
724	18775.143	5.143	P122 (35-0)
725	18774.840	4.840	P107 (34-0)
726	18774.385		

LINE	OBS CM-1	CALC	ASSIGNMENT
727	18774.258	4.259	P 88 (33-0)
728	18774.197	4.198	P 61 (32-0)
		4.168	R137 (36-0)
729	18774.058	4.065	R156 (38-0)
		4.058	R 64 (32-0)
		4.038	P168 (40-0)
		4.006	P145 (37-0)
730	18773.777		
731	18773.679	3.683	R 91 (33-0)
		3.671	R110 (34-0)
		3.617	R170 (40-0)
732	18773.255	3.256	R125 (35-0)
733	18773.130	3.136	P154 (38-0)
734	18772.616		
735	18772.280	2.283	P135 (36-0)
		2.278	P 62 (32-0)
736	18772.136	2.134	R 65 (32-0)
737	18771.992		
738	18771.452	1.452	P 89 (33-0)
739	18771.354	1.355	P108 (34-0)
740	18771.074	1.074	P123 (35-0)
	18770.965	0.964	R164 (39-0)
741	18770.865	0.865	R 92 (33-0)
	18770.679	0.681	P162 (39-0)
	18770.607		
742	18770.329	0.374	R148 (37-0)
		0.328	P 63 (32-0)
743	18770.175	0.179	R 66 (32-0)
		0.167	R111 (34-0)
	18769.999		
744	18769.546	9.552	R138 (36-0)
745	18769.162	9.161	R126 (35-0)
	18768.923	8.918	P146 (37-0)

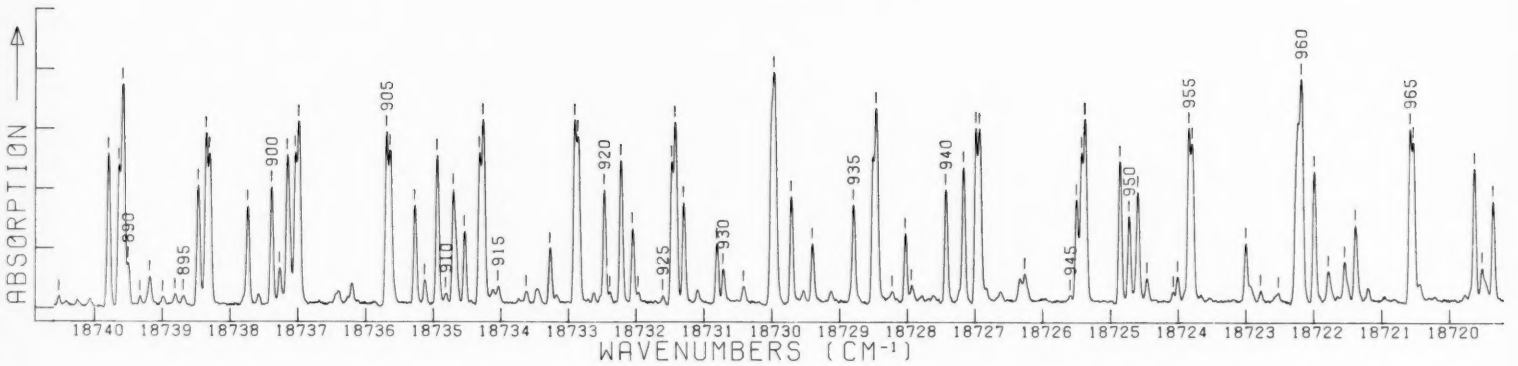
LINE	OBS CM-1	CALC	ASSIGNMENT
746	18768.614	8.614	P 90 (33-0)
	18768.510	8.503	R157 (38-0)
747	18768.348	8.347	P 64 (32-0)
748	18768.196	8.194	R 67 (32-0)
749	18768.016	8.015	R 93 (33-0)
750	18767.942		
751	18767.836	7.836	P109 (34-0)
752	18767.660	7.666	P136 (36-0)
		7.647	P169 (40-0)
	18767.589	7.587	P155 (38-0)
753	18767.333		
	18767.194	7.195	R171 (40-0)
754	18767.097		
755	18766.930	6.970	P124 (35-0)
		6.936	R 1 (31-0)
		6.922	R 2 (31-0)
		6.921	R 0 (31-0)
		6.879	R 3 (31-0)
756	18766.803	6.806	R 4 (31-0)
		6.801	P 1 (31-0)
757	18766.700	6.703	R 5 (31-0)
		6.697	P 2 (31-0)
758	18766.629	6.630	R112 (34-0)
759	18766.567	6.571	R 6 (31-0)
		6.563	P 3 (31-0)
760	18766.404	6.410	R 7 (31-0)
		6.400	P 4 (31-0)
761	18766.336	6.335	P 65 (32-0)
762	18766.185	6.218	R 8 (31-0)
		6.208	P 5 (31-0)
		6.177	R 68 (32-0)
763	18765.992	5.998	R 9 (31-0)
		5.986	P 6 (31-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
764	18765.741	5.748	R 10 (31-0)
		5.743	P 91 (33-0)
		5.734	P 7 (31-0)
765	18765.579		
766	18765.462	5.468	R 11 (31-0)
		5.453	P 8 (31-0)
	18765.233	5.242	R149 (37-0)
767	18765.141	5.159	R 12 (31-0)
		5.142	P 9 (31-0)
		5.133	R 94 (33-0)
768	18765.033	5.030	R127 (35-0)
769	18764.901	4.942	R165 (39-0)
		4.899	R139 (36-0)
770	18764.812	4.820	R 13 (31-0)
		4.802	P 10 (31-0)
	18764.682	4.682	P163 (39-0)
	18764.643		
771	18764.532		
772	18764.440	4.452	R 14 (31-0)
		4.432	P 11 (31-0)
773	18764.292	4.293	P 66 (32-0)
		4.284	P110 (34-0)
774	18764.132	4.130	R 69 (32-0)
775	18764.046	4.054	R 15 (31-0)
		4.033	P 12 (31-0)
	18763.892		
776	18763.785	3.792	P147 (37-0)
777	18763.612	3.627	R 16 (31-0)
		3.604	P 13 (31-0)
	18763.440		
778	18763.160	3.170	R 17 (31-0)
		3.146	P 14 (31-0)
779	18763.056	3.059	R113 (34-0)
		3.012	P137 (36-0)

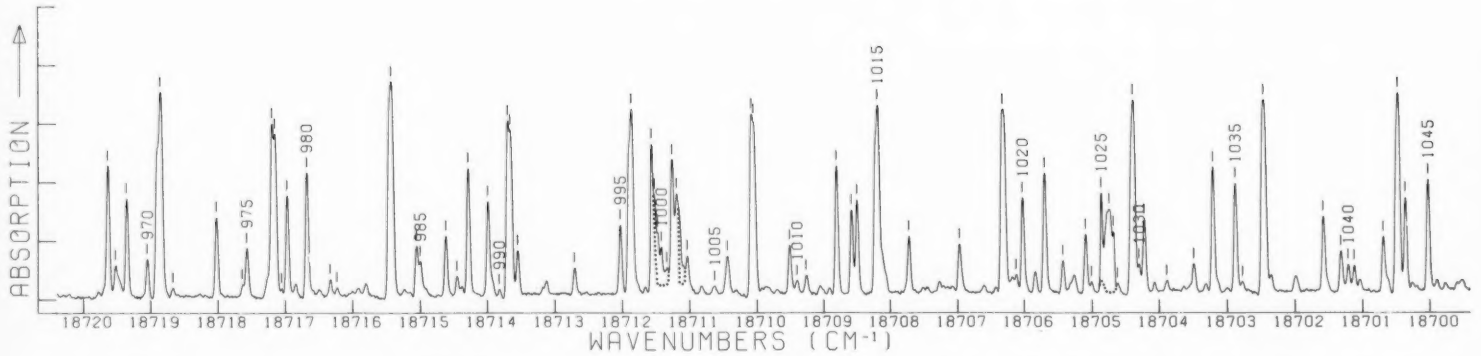
LINE	OBS CM-1	CALC	ASSIGNMENT
780	18762.839	2.900	R158 (38-0)
		2.841	P 92 (33-0)
		2.832	P125 (35-0)
781	18762.668	2.684	R 18 (31-0)
		2.658	P 15 (31-0)
	18762.512		
	18762.421		
782	18762.218	2.220	P 67 (32-0)
		2.219	R 95 (33-0)
783	18762.161	2.168	R 19 (31-0)
		2.141	P 16 (31-0)
784	18762.053	2.052	R 70 (32-0)
	18762.001	1.998	P156 (38-0)
785	18761.873		
786	18761.604	1.622	R 20 (31-0)
		1.594	P 17 (31-0)
787	18761.264		
CALC	**********	1.212	P170 (40-0)
788	18761.034	1.047	R 21 (31-0)
		1.018	P 18 (31-0)
789	18760.863	0.865	R128 (35-0)
790	18760.698	0.728	R172 (40-0)
		0.699	P111 (34-0)
791	18760.600		
792	18760.421	0.442	R 22 (31-0)
		0.412	P 19 (31-0)
793	18760.207	0.210	R140 (36-0)
794	18760.118	0.116	P 68 (32-0)
		0.072	R150 (37-0)
795	18759.935	9.943	R 71 (32-0)
		9.907	P 93 (33-0)
796	18759.795	9.808	R 23 (31-0)
		9.776	P 20 (31-0)
	18759.678		



LINE	OBS CM-1	CALC	ASSIGNMENT
792	18760.421	0.442	R 22 (31-0)
		0.412	P 19 (31-0)
793	18760.207	0.210	R140 (36-0)
794	18760.118	0.116	P 68 (32-0)
		0.072	R150 (37-0)
795	18759.935	9.943	R 71 (32-0)
		9.907	P 93 (33-0)
796	18759.795	9.808	R 23 (31-0)
		9.776	P 20 (31-0)
	18759.678		
797	18759.453	9.454	R114 (34-0)
798	18759.271	9.272	R 96 (33-0)
799	18759.119	9.144	R 24 (31-0)
		9.111	P 21 (31-0)
	18758.971		
800	18758.865	8.878	R166 (39-0)
801	18758.650	8.659	P126 (35-0)
		8.641	P164 (39-0)
		8.628	P148 (37-0)
802	18758.569		
803	18758.440	8.451	R 25 (31-0)
		8.417	P 22 (31-0)
804	18758.318	8.322	P138 (36-0)
	18758.230		
805	18757.984	7.982	P 69 (32-0)
806	18757.806	7.804	R 72 (32-0)
807	18757.699	7.728	R 26 (31-0)
		7.693	P 23 (31-0)
	18757.459		
808	18757.303		
809	18757.212	7.256	R159 (38-0)
810	18757.079	7.080	P112 (34-0)
811	18756.946	6.975	R 27 (31-0)
		6.940	P 94 (33-0)
		6.939	P 24 (31-0)
812	18756.660	6.664	R129 (35-0)
	18756.525		
813	18756.294	6.369	P157 (38-0)
		6.293	R 97 (33-0)
814	18756.159	6.193	R 28 (31-0)
		6.155	P 25 (31-0)
815	18755.816	5.817	P 70 (32-0)
		5.816	R115 (34-0)
816	18755.634	5.633	R 73 (32-0)
817	18755.481	5.484	R141 (36-0)
818	18755.375	5.381	R 29 (31-0)
		5.342	P 26 (31-0)
819	18754.858	4.862	R151 (37-0)
	18754.729	4.732	P171 (40-0)
820	18754.501	4.539	R 30 (31-0)
		4.500	P 27 (31-0)
		4.451	P127 (35-0)
	18754.212	4.216	R173 (40-0)
821	18753.942	3.942	P 95 (33-0)
822	18753.626	3.668	R 31 (31-0)
		3.628	P 28 (31-0)
		3.621	P 71 (32-0)
		3.596	P139 (36-0)
823	18753.431	3.432	R 74 (32-0)
		3.428	P113 (34-0)
		3.426	P149 (37-0)
824	18753.281	3.283	R 98 (33-0)
825	18753.082		
826	18753.014		
827	18752.727	2.772	R167 (39-0)
		2.767	R 32 (31-0)
		2.726	P 29 (31-0)
	18752.555	2.558	P165 (39-0)
828	18752.426	2.428	R130 (35-0)
829	18752.303		
830	18752.140	2.144	R116 (34-0)
	18751.977		
831	18751.834	1.837	R 33 (31-0)
		1.795	P 30 (31-0)
832	18751.560	1.572	R160 (38-0)
833	18751.396	1.394	P 72 (32-0)
834	18751.202	1.200	R 75 (32-0)
835	18751.108		
836	18750.880	0.912	P 96 (33-0)
		0.877	R 34 (31-0)
837	18750.835	0.834	P 31 (31-0)
838	18750.715	0.721	R142 (36-0)
		0.700	P158 (38-0)
	18750.593		
839	18750.535		
	18750.427		
840	18750.236	0.239	R 99 (33-0)
		0.208	P128 (35-0)
841	18750.145		
	18750.066		
842	18749.886	9.887	R 35 (31-0)
843	18749.848	9.843	P 32 (31-0)
844	18749.742	9.743	P114 (34-0)
845	18749.608	9.614	R152 (37-0)
846	18749.470		
	18749.353		
847	18749.138	9.137	P 73 (32-0)
848	18748.938	8.936	R 76 (32-0)
849	18748.823	8.867	R 36 (31-0)
		8.833	P140 (36-0)
		8.823	P 33 (31-0)
850	18748.672		
851	18748.437	8.438	R117 (34-0)
	18748.307		
	18748.302		
852	18748.160	8.185	P150 (37-0)
		8.157	R131 (35-0)
853	18747.944		
854	18747.826	7.849	P 97 (33-0)
		7.818	R 37 (31-0)
855	18747.776	7.773	P 34 (31-0)
	18747.670		
856	18747.244		
857	18747.164	7.164	R100 (33-0)
858	18746.850	6.848	P 74 (32-0)
859	18746.688	6.739	R 38 (31-0)
		6.694	P 35 (31-0)
860	18746.650	6.642	R 77 (32-0)
		6.622	R168 (39-0)
	18746.448	6.433	P166 (39-0)
861	18746.024	6.024	P115 (34-0)
862	18745.926	5.930	P129 (35-0)
		5.922	R143 (36-0)
	18745.845	5.847	R161 (38-0)
863	18745.631	5.631	R 39 (31-0)
864	18745.584	5.585	P 36 (31-0)
865	18745.334		
	18744.990	4.990	P159 (38-0)
866	18744.895		
867	18744.754	4.754	P 98 (33-0)
868	18744.702	4.698	R118 (34-0)
869	18744.510	4.529	P 75 (32-0)
		4.492	R 40 (31-0)
870	18744.445	4.446	P 37 (31-0)
871	18744.320	4.328	R153 (37-0)
		4.317	R 78 (32-0)
	18744.200		
872	18744.052	4.056	R101 (33-0)
		4.033	P141 (36-0)
873	18743.848	3.851	R132 (35-0)
	18743.672		
	18743.456		
874	18743.325	3.324	R 41 (31-0)
875	18743.278	3.277	P 38 (31-0)
	18743.190		
876	18743.109		
	18742.908	2.907	P151 (37-0)
877	18742.403		
878	18742.271	2.272	P116 (34-0)
879	18742.179	2.179	P 76 (32-0)
880	18742.078	2.126	R 42 (31-0)
		2.079	P 39 (31-0)
881	18741.963	1.961	R 79 (32-0)
	18741.843		
	18741.732		
882	18741.625	1.627	P 99 (33-0)
		1.617	P130 (35-0)
883	18741.086	1.085	R144 (36-0)
884	18740.907	0.925	R119 (34-0)
		0.916	R102 (33-0)
		0.899	R 43 (31-0)
885	18740.853	0.851	P 40 (31-0)
886	18740.523		
	18740.429	0.430	R169 (39-0)
	18740.263	0.265	P167 (39-0)
	18740.078	0.081	R162 (38-0)
887	18739.798	9.798	P 77 (32-0)
888	18739.642	9.641	R 44 (31-0)
889	18739.585	9.593	P 41 (31-0)
		9.574	R 80 (32-0)
890	18739.509	9.509	R133 (35-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
886	18740.523		
	18740.429	0.430	R169 (39-0)
	18740.263	0.265	P167 (39-0)
	18740.078	0.081	R162 (38-0)
887	18739.798	9.798	P 77 (32-0)
888	18739.642	9.641	R 44 (31-0)
889	18739.585	9.593	P 41 (31-0)
		9.574	R 80 (32-0)
890	18739.509	9.509	R133 (35-0)
891	18739.333		
892	18739.189	9.240	P160 (38-0)
		9.196	P142 (36-0)
893	18738.994	9.002	R154 (37-0)
894	18738.814		
895	18738.694		
896	18738.474	8.485	P117 (34-0)
		8.468	P100 (33-0)
897	18738.356	8.354	R 45 (31-0)
898	18738.307	8.306	P 42 (31-0)
899	18737.742	7.744	R103 (33-0)
	18737.591	7.589	P152 (37-0)
900	18737.388	7.387	P 78 (32-0)
901	18737.269	7.269	P131 (35-0)
902	18737.155	7.156	R 81 (32-0)
		7.118	R120 (34-0)
903	18737.037	7.037	R 46 (31-0)
904	18736.989	6.989	P 43 (31-0)
	18736.410		
	18736.215	6.211	R145 (36-0)
905	18735.693	5.691	R 47 (31-0)
906	18735.643	5.642	P 44 (31-0)
907	18735.277	5.277	P101 (33-0)
908	18735.130	5.131	R134 (35-0)
909	18734.945	4.944	P 79 (32-0)
910	18734.815		
911	18734.705	4.706	R 82 (32-0)
		4.666	P118 (34-0)
		4.539	R104 (33-0)
912	18734.538		
913	18734.316	4.323	P143 (36-0)
		4.314	R 48 (31-0)
914	18734.264	4.275	R163 (38-0)
		4.266	P 45 (31-0)
	18734.132		
915	18734.044	4.055	P168 (39-0)
	18733.755		
916	18733.627	3.638	R155 (37-0)
	18733.475	3.450	P161 (38-0)
917	18733.275	3.277	R121 (34-0)
	18733.182		
918	18732.907	2.908	R 49 (31-0)
919	18732.863	2.886	P132 (35-0)
		2.859	P 46 (31-0)
	18732.639		
920	18732.471	2.470	P 80 (32-0)
921	18732.389		
922	18732.226	2.234	P153 (37-0)
		2.226	R 83 (32-0)
923	18732.053	2.054	P102 (33-0)
924	18731.969		
925	18731.608		
926	18731.472	1.471	R 50 (31-0)
927	18731.422	1.423	P 47 (31-0)
928	18731.300	1.301	R105 (33-0)
		1.300	R146 (36-0)
	18731.107		
929	18730.811	0.812	P119 (34-0)
930	18730.718	0.719	R135 (35-0)
931	18730.419		
932	18729.964	0.005	R 5' 31-0)
		9.965	P 8. 32-0)
		9.957	P 48 (31-0)
933	18729.715	9.714	R 84 (32-0)
	18729.545		
934	18729.403	9.413	P144 (36-0)
		9.402	R122 (34-0)
	18729.139		
935	18728.797	8.798	P103 (33-0)
936	18728.461	8.509	R 52 (31-0)
		8.467	P133 (35-0)
		8.462	P 49 (31-0)
		8.427	R164 (38-0)
937	18728.226	8.234	R156 (37-0)
938	18728.030	8.031	R106 (33-0)
939	18727.937		
	18727.802	7.802	P169 (39-0)
	18727.622	7.619	P162 (38-0)
940	18727.429	7.430	P 82 (32-0)
941	18727.172	7.171	R 85 (32-0)
942	18726.985	6.983	R 53 (31-0)
943	18726.934	6.936	P 50 (31-0)
		6.925	P120 (34-0)
	18726.845	6.839	P154 (37-0)
	18726.632		
	18726.347	6.351	R147 (36-0)
944	18726.271	6.270	R136 (35-0)
945	18725.594		
946	18725.502	5.509	P104 (33-0)
		5.493	R123 (34-0)
947	18725.429	5.428	R 54 (31-0)
948	18725.380	5.381	P 51 (31-0)
949	18724.864	4.863	P 83 (32-0)
950	18724.727	4.729	R107 (33-0)
951	18724.598	4.598	R 86 (32-0)
952	18724.464	4.466	P145 (36-0)
953	18724.075		
954	18724.013	4.013	P134 (35-0)
955	18723.843	3.842	R 55 (31-0)
956	18723.797	3.796	P 52 (31-0)
957	18723.004	3.004	P121 (34-0)
	18722.941		
958	18722.785	2.791	R157 (37-0)
959	18722.523	2.538	R165 (38-0)
960	18722.183	2.265	P 84 (32-0)
		2.226	R 56 (31-0)
		2.189	P105 (33-0)
		2.180	P 53 (31-0)
961	18721.992	1.992	R 87 (32-0)
962	18721.784	1.786	R137 (35-0)
		1.748	R163 (38-0)
963	18721.548	1.550	R124 (34-0)
		1.507	P170 (39-0)
964	18721.390	1.406	P155 (37-0)
		1.393	R108 (33-0)
		1.365	R148 (36-0)
	18721.213		
965	18720.581	0.581	R 57 (31-0)
966	18720.537	0.536	P 54 (31-0)
	18720.450		
967	18719.636	9.636	P 85 (32-0)
968	18719.521	9.524	P135 (35-0)
		9.482	P146 (36-0)
969	18719.357	9.356	R 88 (32-0)



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968	18719.521	9.524	P135 (35-0)
		9.482	P146 (36-0)
969	18719.357	9.356	R 88 (32-0)
970	18719.049	9.049	P122 (34-0)
971	18718.856	8.905	R 58 (31-0)
		8.861	P 55 (31-0)
		8.836	P106 (33-0)
972	18718.665		
973	18718.024	8.026	R109 (33-0)
974	18717.636		
975	18717.571	7.572	R125 (34-0)
	18717.277	7.309	R158 (37-0)
		7.267	R138 (35-0)
976	18717.200	7.199	R 59 (31-0)
977	18717.158	7.156	P 56 (31-0)
978	18717.058		
979	18716.977	6.976	P 86 (32-0)
	18716.866		
980	18716.689	6.688	R 89 (32-0)
	18716.604	6.607	R166 (38-0)
	18716.508		
981	18716.338	6.342	R149 (36-0)
982	18716.236		
	18715.929	5.934	P156 (37-0)
	18715.815	5.835	P164 (38-0)
983	18715.430	5.464	R 60 (31-0)
		5.450	P107 (33-0)
		5.421	P 57 (31-0)
	18715.167	5.168	P171 (39-0)
984	18715.058	5.060	P123 (34-0)
985	18715.003	5.000	P136 (35-0)
986	18714.623	4.625	R110 (33-0)
987	18714.454	4.461	P147 (36-0)
	18714.389		
988	18714.285	4.285	P 87 (32-0)
989	18713.990	3.989	R 90 (32-0)
990	18713.827		
991	18713.698	3.698	R 61 (31-0)
992	18713.663	3.657	P 58 (31-0)
993	18713.557	3.561	R126 (34-0)
	18713.137		
994	18712.712	2.711	R139 (35-0)
995	18712.030	2.032	P108 (33-0)
996	18711.863	1.903	R 62 (31-0)
		1.862	P 59 (31-0)
	18711.790	1.787	R159 (37-0)
	18711.670		
997	18711.565	1.563	P 88 (32-0)
998	18711.523	*****	ARTIFACT
999	18711.475	*****	ARTIFACT
1000	18711.419	*****	ARTIFACT
	18711.383		
1001	18711.340	*****	ARTIFACT
1002	18711.260	1.282	R150 (36-0)
		1.259	R 91 (32-0)
1003	18711.193	1.192	R111 (33-0)
1004	18711.036	1.038	P124 (34-0)
	18710.832		
1005	18710.630	0.635	R167 (38-0)
1006	18710.435	0.439	P137 (35-0)
		0.423	P157 (37-0)
1007	18710.076	0.077	R 63 (31-0)
1008	18710.049	0.038	P 60 (31-0)
	18709.884	9.882	P165 (38-0)
1009	18709.513	9.515	R127 (34-0)
1010	18709.399	9.403	P148 (36-0)
1011	18709.261		
	18709.065		
	18708.924		
1012	18708.810	8.809	P 89 (32-0)
1013	18708.580	8.582	P109 (33-0)
1014	18708.497	8.498	R 92 (32-0)
1015	18708.186	8.221	R 64 (31-0)
		8.184	P 61 (31-0)
	18708.125	8.120	R140 (35-0)
1016	18707.725	7.726	R112 (33-0)
	18707.284		
1017	18706.977	6.981	P125 (34-0)
		6.947	R 19 (37-2)
		6.620	P 17 (37-2)
	18706.622		
	18706.437		
1018	18706.327	6.335	R 65 (31-0)
		6.335	R 20 (37-2)
		6.299	P 62 (31-0)
	18706.187	6.226	R160 (37-0)
		6.183	R151 (36-0)
1019	18706.123		
1020	18706.025	6.024	P 90 (32-0)
		5.990	P 18 (37-2)
	18705.848	5.844	P138 (35-0)
1021	18705.703	5.705	R 93 (32-0)
		5.690	R 21 (37-2)
1022	18705.432	5.435	R128 (34-0)
	18705.278	5.328	P 19 (37-2)
1023	18705.097	5.099	P110 (33-0)
1024	18705.010	5.012	R 22 (37-2)
	18704.872	4.873	P158 (37-0)
1025	18704.864	*****	ARTIFACT
1026	18704.744	*****	ARTIFACT
1027	18704.684	*****	ARTIFACT
1028	18704.624	4.633	P 20 (37-2)
		4.622	R168 (38-0)
1029	18704.389	4.419	R 66 (31-0)
		4.385	P 63 (31-0)
1030	18704.302	4.308	P149 (36-0)
		4.302	R 23 (37-2)
1031	18704.226	4.227	R113 (33-0)
	18704.081		
1032	18703.889	3.906	P 21 (37-2)
		3.888	P166 (38-0)
1033	18703.494	3.559	R 24 (37-2)
		3.493	R141 (35-0)
	18703.324		
1034	18703.208	3.208	P 91 (32-0)
	18703.152	3.145	P 22 (37-2)
1035	18702.882	2.890	P126 (34-0)
		2.880	R 94 (32-0)
1036	18702.774	2.783	R 25 (37-2)
1037	18702.458	2.473	R 67 (31-0)
		2.440	P 64 (31-0)
	18702.356	2.352	P 23 (37-2)
	18701.998	1.975	R 26 (37-2)
1038	18701.582	1.583	P111 (33-0)
		1.526	P 24 (37-2)
1039	18701.521	1.321	R129 (34-0)
1040	18701.213	1.213	P139 (35-0)
1041	18701.125	1.133	R 27 (37-2)
	18701.052	1.047	R152 (36-0)
1042	18700.692	0.696	R114 (33-0)
		0.668	P 25 (37-2)
		0.626	R161 (37-0)
1043	18700.471	0.497	R 68 (31-0)
		0.466	P 65 (31-0)
1044	18700.361	0.361	P 92 (32-0)
	18700.260	0.259	R 28 (37-2)
1045	18700.024	0.024	R 95 (32-0)
	18699.900		
	18699.778	9.777	P 26 (37-2)
	18699.605		
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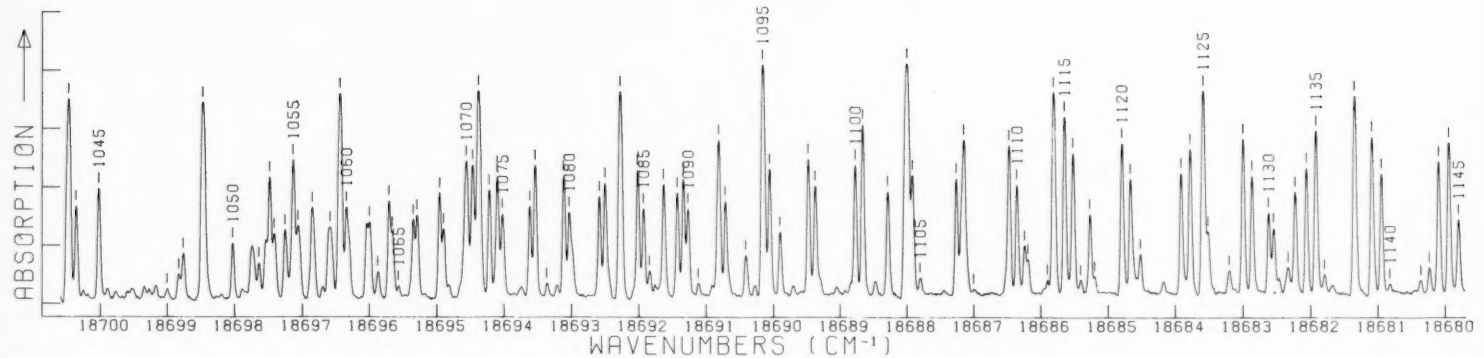

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		0.466	P 65 (31-0)
1044	18700.361	0.361	P 92 (32-0)
	18700.260	0.259	R 28 (37-2)
1045	18700.024	0.024	R 95 (32-0)
	18699.900		
	18699.778	9.777	P 26 (37-2)
	18699.605		
	18699.536		
	18699.353	9.352	R 29 (37-2)
	18699.282	9.283	P159 (37-0)
	18699.182	9.175	P150 (36-0)
1046	18699.003		
1047	18698.832	8.852	P 27 (37-2)
		8.830	R142 (35-0)
1048	18698.765	8.766	P127 (34-0)
1049	18698.477	8.567	R169 (38-0)
		8.491	R 69 (31-0)
		8.461	P 66 (31-0)
		8.412	R 30 (37-2)
1050	18698.032	8.034	P112 (33-0)
	18697.894	7.896	P 28 (37-2)
CALC	**********	7.852	P167 (38-0)
CALC	**********	7.767	R 1 (30-0)
CALC	**********	7.755	R 2 (30-0)
CALC	**********	7.750	R 0 (30-0)
CALC	**********	7.714	R 3 (30-0)
1051	18697.644	7.643	R 4 (30-0)
		7.630	P 1 (30-0)
1052	18697.483	7.544	R 5 (30-0)
		7.526	P 2 (30-0)
		7.482	P 93 (32-0)
1053	18697.415	7.440	R 31 (37-2)
		7.416	R 6 (30-0)
		7.394	P 3 (30-0)
1054	18697.254	7.259	R 7 (30-0)
		7.232	P 4 (30-0)
1055	18697.134	7.172	R130 (34-0)
		7.137	R 96 (32-0)
		7.131	R115 (33-0)
1056	18697.064	7.073	R 8 (30-0)
		7.042	P 5 (30-0)
1057	18696.853	6.906	P 29 (37-2)
		6.858	R 9 (30-0)
		6.823	P 6 (30-0)
	18696.704		
1058	18696.583	6.615	R 10 (30-0)
		6.574	P 7 (30-0)
		6.546	P140 (35-0)
1059	18696.434	6.454	R 70 (31-0)
		6.434	R 32 (37-2)
		6.427	P 67 (31-0)
1060	18696.340	6.342	R 11 (30-0)
		6.297	P 8 (30-0)
1061	18695.995	6.040	R 12 (30-0)
		5.991	P 9 (30-0)
1062	18695.872	5.884	P 30 (37-2)
		5.874	R153 (36-0)
1063	18695.708	5.709	R 13 (30-0)
1064	18695.662	5.656	P 10 (30-0)
1065	18695.572		
1066	18695.350	5.396	R 33 (37-2)
		5.349	R 14 (30-0)
1067	18695.294	5.291	P 11 (30-0)
1068	18694.961	4.985	R162 (37-0)
		4.961	R 15 (30-0)
1069	18694.901	4.898	P 12 (30-0)
	18694.830	4.828	P 31 (37-2)
1070	18694.560	4.607	P128 (34-0)
		4.572	P 94 (32-0)
		4.543	R 16 (30-0)
1071	18694.465	4.476	P 13 (30-0)
		4.453	P113 (33-0)
1072	18694.375	4.347	R 71 (31-0)
		4.362	P 68 (31-0)
		4.325	R 34 (37-2)
1073	18694.216	4.218	R 97 (32-0)
1074	18694.098	4.130	R143 (35-0)
		4.096	R 17 (30-0)
1075	18694.024	4.025	P 14 (30-0)
		4.005	P151 (36-0)
	18693.754	3.740	P 32 (37-2)
1076	18693.622	3.655	P160 (37-0)
		3.620	R 18 (30-0)
1077	18693.541	3.545	P 15 (30-0)
		3.534	R116 (33-0)
1078	18693.367		
	18693.223	3.221	R 35 (37-2)
1079	18693.116	3.116	R 19 (30-0)
1080	18693.035	3.036	P 16 (30-0)
		2.989	R131 (34-0)
1081	18692.584	2.620	P 33 (37-2)
		2.582	R 20 (30-0)
1082	18692.499	2.498	P 17 (30-0)
		2.469	R170 (38-0)
1083	18692.274	2.290	R 72 (31-0)
		2.267	P 69 (31-0)
1084	18692.019	2.084	R 36 (37-2)
		2.019	R 21 (30-0)
1085	18691.931	1.931	P 18 (30-0)
1086	18691.841	1.843	P141 (35-0)
	18691.775	1.775	P168 (38-0)
1087	18691.631	1.631	P 95 (32-0)
1088	18691.428	1.466	P 34 (37-2)
		1.427	R 22 (30-0)
1089	18691.336	1.335	P 19 (30-0)
1090	18691.267	1.267	R 98 (32-0)
1091	18691.116		
	18690.915	0.914	R 37 (37-2)
1092	18690.810	0.840	P114 (33-0)
		0.807	R 23 (30-0)
1093	18690.710	0.710	P 20 (30-0)
		0.662	R154 (36-0)
1094	18690.410	0.414	P129 (34-0)
	18690.282	0.279	P 35 (37-2)
1095	18690.155	0.163	R 73 (31-0)
		0.157	R 24 (30-0)
		0.142	P 70 (31-0)
1096	18690.057	0.056	P 21 (30-0)
1097	18689.902	9.903	R117 (33-0)
	18689.710	9.711	R 38 (37-2)
1098	18689.478	9.478	R 25 (30-0)
1099	18689.375	9.395	R144 (35-0)
		9.374	P 22 (30-0)
	18689.316	9.305	R163 (37-0)
	18689.062	9.060	P 36 (37-2)
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		8.772	R132 (34-0)
		8.770	R 26 (30-0)
1101	18688.661	8.662	P 23 (30-0)
		8.658	P 96 (32-0)
	18688.475	8.475	R 39 (37-2)
1102	18688.283	8.285	R 99 (32-0)
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		8.006	R 74 (31-0)
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1104	18687.921	7.921	P 24 (30-0)
1105	18687.805	7.808	P 37 (37-2)
1106	18687.268	7.267	R 28 (30-0)
1107	18687.155	7.206	R 40 (37-2)
		7.193	P115 (33-0)
		7.151	P 25 (30-0)
		7.105	P142 (35-0)
1108	18687.003		
1109	18686.473	6.523	P 38 (37-2)
		6.472	R 29 (30-0)
1110	18686.352	6.352	P 26 (30-0)
		6.330	R171 (38-0)
1111	18686.237	6.240	R118 (33-0)
1112	18686.189	6.186	P130 (34-0)
1113	18685.901	5.905	R 41 (37-2)
1114	18685.810	5.818	R 75 (31-0)
		5.802	P 72 (31-0)
1115	18685.650	5.657	P169 (38-0)
		5.654	P 97 (32-0)
		5.648	R 30 (30-0)
1116	18685.523	5.524	P 27 (30-0)
1117	18685.410	5.412	R155 (36-0)
1118	18685.270	5.272	R100 (32-0)
1119	18685.200	5.205	P 39 (37-2)
1120	18684.795	4.795	R 31 (30-0)
1121	18684.666	4.667	P 28 (30-0)
		4.624	R145 (35-0)
1122	18684.517	4.570	R 42 (37-2)
		4.520	R133 (34-0)
	18684.182		
1123	18683.913	3.913	R 32 (30-0)
		3.854	P 40 (37-2)
1124	18683.781	3.781	P 29 (30-0)
1125	18683.589	3.600	R 76 (31-0)
		3.586	P 73 (31-0)
		3.585	R164 (37-0)
		3.552	P153 (36-0)
1126	18683.515	3.514	P116 (33-0)
1127	18683.204	3.202	R 43 (37-2)
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1129	18682.865	2.866	P 30 (30-0)
1130	18682.619	2.619	P 98 (32-0)
1131	18682.544	2.543	R119 (33-0)
	18682.472	2.470	P 41 (37-2)
1132	18682.330	2.330	P143 (35-0)
		2.280	P162 (37-0)
1133	18682.225	2.226	R101 (32-0)
1134	18682.061	2.061	R 34 (30-0)
1135	18681.920	1.925	P131 (34-0)
		1.921	P 31 (30-0)
1136	18681.793	1.802	R 44 (37-2)
	18681.684		
1137	18681.346	1.351	R 77 (31-0)
		1.340	P 74 (31-0)
113A	18681.091	1.092	R 35 (30-0)
		1.053	P 42 (37-2)
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1142	18680.234	0.233	R134 (34-0)
1143	18680.094	0.149	R172 (38-0)
		0.125	R156 (36-0)
		0.093	R 36 (30-0)
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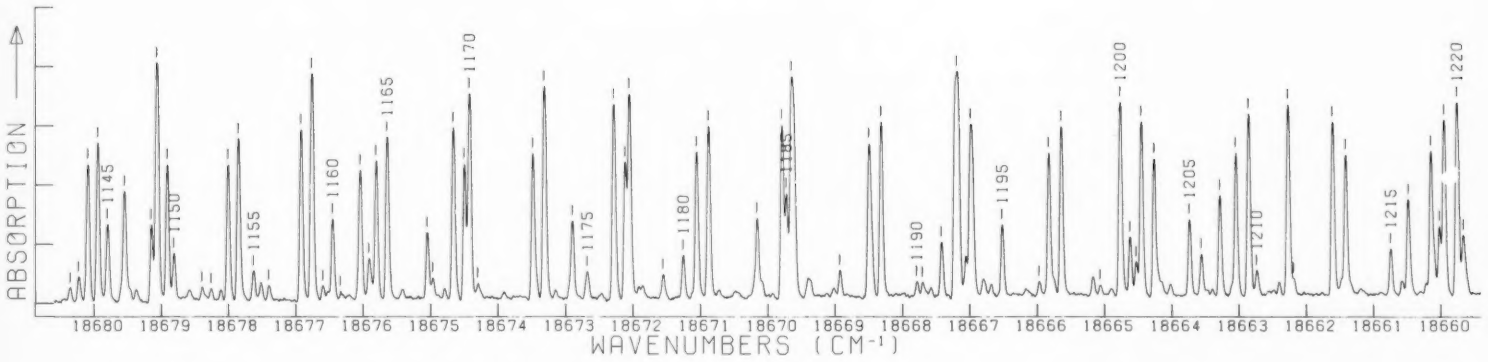
1145	18679.802	9.816	R146 (35-0)
		9.801	P117 (33-0)



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1143	18680.094	0.149	R172 (38-0)
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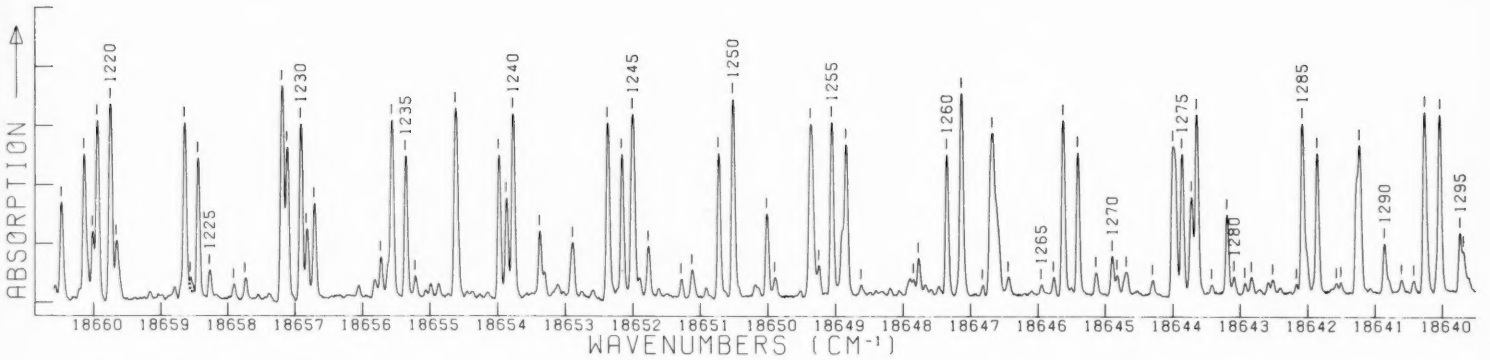
1144	18679.946	9.946	P 33 (30-0)
1145	18679.802	9.816	R146 (35-0)
		9.801	P117 (33-0)
1146	18679.550	9.603	P 43 (37-2)
		9.551	P 99 (32-0)
	18679.484	9.497	P170 (38-0)
	18679.382		
1147	18679.148	9.149	R102 (32-0)
1148	18679.065	9.072	R 78 (31-0)
		9.065	R 37 (30-0)
		9.064	P 75 (31-0)
1149	18678.914	8.915	P 34 (30-0)
		8.901	R 46 (37-2)
1150	18678.814	8.814	R120 (33-0)
	18678.588		
1151	18678.396		
1152	18678.259	8.269	P154 (36-0)
	18678.123	8.120	P 44 (37-2)
1153	18678.007	8.008	R 38 (30-0)
1154	18677.853	7.854	P 35 (30-0)
		7.825	R165 (37-0)
1155	18677.625	7.629	P132 (34-0)
	18677.524	7.520	P144 (35-0)
1156	18677.399	7.401	R 47 (37-2)
1157	18676.922	6.922	R 39 (30-0)
1158	18676.761	6.765	P 36 (30-0)
		6.763	R 79 (31-0)
		6.758	P 76 (31-0)
1159	18676.598	6.605	P 45 (37-2)
	18676.529	6.533	P163 (37-0)
1160	18676.452	6.453	P100 (32-0)
1161	18676.336		
1162	18676.043	6.056	P118 (33-0)
		6.041	R103 (32-0)
1163	18675.913	5.911	R135 (34-0)
		5.868	R 48 (37-2)
1164	18675.807	5.807	R 40 (30-0)
1165	18675.645	5.646	P 37 (30-0)
	18675.430		
1166	18675.050	5.056	P 46 (37-2)
		5.051	R121 (33-0)
1167	18674.969	4.972	R147 (35-0)
	18674.798	4.799	R157 (36-0)
1168	18674.662	4.662	R 41 (30-0)
1169	18674.497	4.498	P 38 (30-0)
1170	18674.421	4.423	R 80 (31-0)
		4.422	P 77 (31-0)
1171	18674.299	4.302	R 49 (37-2)
	18673.922	3.925	R173 (38-0)
1172	18673.487	3.489	R 42 (30-0)
		3.474	P 47 (37-2)
1173	18673.318	3.323	P101 (32-0)
		3.321	P 39 (30-0)
		3.298	P133 (34-0)
		3.295	P171 (38-0)
	18673.157		
1174	18672.898	2.949	P155 (36-0)
		2.900	R104 (32-0)
1175	18672.679	2.703	R 50 (37-2)
		2.674	P145 (35-0)
	18672.473		
1176	18672.283	2.286	R 43 (30-0)
		2.278	P119 (33-0)
1177	18672.114	2.115	P 40 (30-0)
1178	18672.053	2.055	P 78 (31-0)
		2.053	R 81 (31-0)
		2.024	R166 (37-0)
	18671.920		
	18671.865	1.859	P 48 (37-2)
1179	18671.552	1.555	R136 (34-0)
1180	18671.254	1.255	R122 (33-0)
1181	18671.055	1.071	R 51 (37-2)
		1.054	R 44 (30-0)
1182	18670.880	0.880	P 41 (30-0)
	18670.738	0.746	P164 (37-0)
	18670.485		
1183	18670.160	0.212	P 49 (37-2)
		0.161	P102 (32-0)
	18670.098	0.091	R148 (35-0)
1184	18669.792	9.793	R 45 (30-0)
1185	18669.727	9.728	R105 (32-0)
1186	18669.646	9.658	P 79 (31-0)
		9.653	R 82 (31-0)
		9.616	P 42 (30-0)
	18669.410	9.435	R158 (36-0)
		9.405	R 52 (37-2)
	18669.031		
1187	18668.932	8.933	P134 (34-0)
1188	18668.500	8.531	P 50 (37-2)
		8.502	R 46 (30-0)
		8.467	P120 (33-0)
1189	18668.322	8.322	P 43 (30-0)
1190	18667.794	7.791	P146 (35-0)
1191	18667.706	7.707	R 53 (37-2)
		7.659	R174 (38-0)
	18667.590	7.590	P156 (36-0)
1192	18667.425	7.426	R123 (33-0)
1193	18667.190	7.230	P 80 (31-0)
		7.222	R 83 (31-0)
		7.183	R 47 (30-0)
		7.164	R137 (34-0)
CALC	**********	7.051	P172 (38-0)
1194	18666.988	7.000	P 44 (30-0)
		6.967	P103 (32-0)
		6.817	P 51 (37-2)
	18666.807		
	18666.694		
1195	18666.522	6.524	R106 (32-0)
	18666.178	6.183	R167 (37-0)
1196	18665.975	5.975	R 54 (37-2)
1197	18665.833	5.834	R 48 (30-0)
1198	18665.647	5.648	P 45 (30-0)
	18665.177	5.174	R149 (35-0)
1199	18665.065	5.069	P 52 (37-2)
	18664.907	4.920	P165 (37-0)
1200	18664.765	4.772	P 81 (31-0)
		4.760	R 84 (31-0)
1201	18664.620	4.623	P121 (33-0)
1202	18664.531	4.534	P135 (34-0)
1203	18664.454	4.456	R 49 (30-0)
1204	18664.266	4.267	P 46 (30-0)
	18664.217	4.210	R 55 (37-2)
	18664.164		
	18664.029	4.033	R159 (36-0)
1205	18663.740	3.742	P104 (32-0)
1206	18663.562	3.563	R124 (33-0)
1207	18663.285	3.289	P 53 (37-2)
		3.288	R107 (32-0)
1208	18663.048	3.048	R 50 (30-0)
1209	18662.857	2.873	P147 (35-0)
		2.857	P 47 (30-0)
1210	18662.738	2.738	R138 (34-0)
	18662.412	2.411	R 56 (37-2)
1211	18662.273	2.284	P 82 (31-0)
		2.268	R 85 (31-0)
1212	18662.192	2.194	P157 (36-0)
1213	18661.611	1.611	R 51 (30-0)
	18661.480	1.476	P 54 (37-2)
1214	18661.417	1.417	P 48 (30-0)
		1.350	R175 (38-0)
1215	18660.743	0.765	P173 (38-0)
		0.745	P122 (33-0)
	18660.579	0.580	R 57 (37-2)
1216	18660.483	0.486	P105 (32-0)
	18660.300	0.302	R168 (37-0)
	18660.220	0.221	R150 (35-0)
1217	18660.145	0.145	R 52 (30-0)
		0.100	P136 (34-0)
1218	18660.017	0.020	R108 (32-0)
1219	18659.948	9.949	P 49 (30-0)
1220	18659.755	9.765	P 83 (31-0)
		9.746	R 86 (31-0)
1221	18659.663	9.668	R125 (33-0)
		9.629	P 55 (37-2)



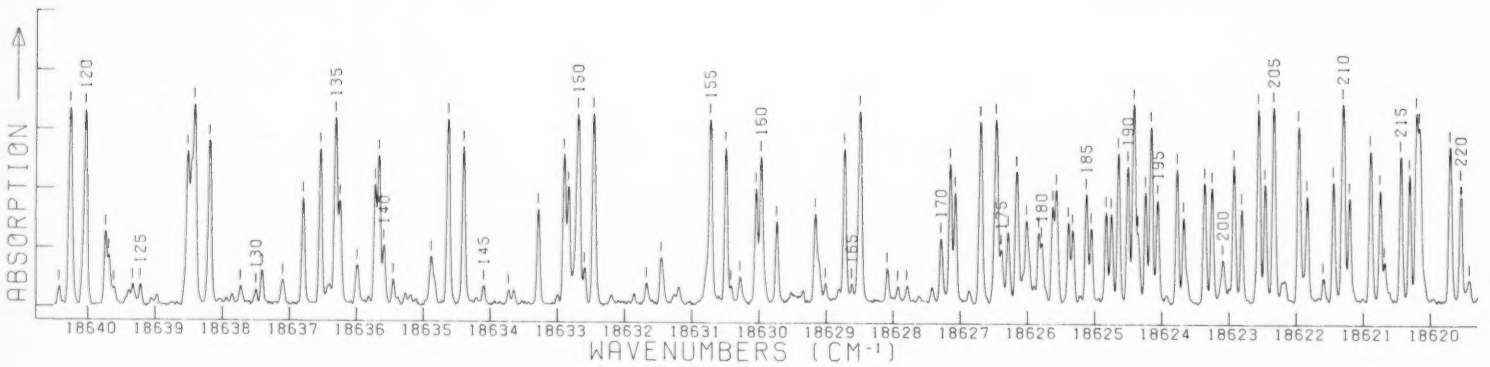
LINE	OBS CM-1	CALC	ASSIGNMENT
1216	18660.483	0.486	P105 (32-0)
	18660.300	0.302	R168 (37-0)
	18660.220	0.221	R150 (35-0)
1217	18660.145	0.145	R 52 (30-0)
		0.100	P136 (34-0)
1218	18660.017	0.020	R108 (32-0)
1219	18659.948	9.949	P 49 (30-0)
1220	18659.755	9.765	P 83 (31-0)
		9.746	R 86 (31-0)
1221	18659.663	9.668	R125 (33-0)
		9.629	P 55 (37-2)
	18659.167		
	18659.043	9.054	P166 (37-0)
	18658.992		
	18658.804		
1222	18658.648	8.715	R 58 (37-2)
		8.650	R 53 (30-0)
		8.592	R160 (36-0)
1223	18658.562	*****	ARTIFACT
1224	18658.449	8.451	P 50 (30-0)
1225	18658.277	8.278	R139 (34-0)
1226	18657.916	7.918	P148 (35-0)
1227	18657.746	7.749	P 56 (37-2)
	18657.567		
	18657.397		
1228	18657.199	7.216	P 84 (31-0)
		7.197	P106 (32-0)
		7.193	R 87 (31-0)
1229	18657.124	7.125	R 54 (30-0)
1230	18656.922	6.923	P 51 (30-0)
1231	18656.831	6.835	P123 (33-0)
		6.817	R 59 (37-2)
1232	18656.719	6.760	P158 (36-0)
		6.720	R109 (32-0)
	18656.072		
	18655.824	5.836	P 57 (37-2)
1233	18655.736	5.738	R126 (33-0)
	18655.628	5.631	P137 (34-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
1234	18655.570	5.571	R 55 (30-0)
1235	18655.366	5.367	P 52 (30-0)
1236	18655.226	5.231	R151 (35-0)
	18655.074		
	18655.000	4.998	R176 (38-0)
	18654.883	4.885	R 60 (37-2)
1237	18654.622	4.637	P 85 (31-0)
		4.609	R 88 (31-0)
CALC	*********	4.438	P174 (38-0)
	18654.379	4.380	R169 (37-0)
	18654.276	4.271	P 8 (36-2)
	18654.157	4.153	R 11 (36-2)
1238	18653.986	3.988	R 56 (30-0)
		3.941	P 9 (36-2)
1239	18653.876	3.890	P 58 (37-2)
		3.877	P107 (32-0)
1240	18653.780	3.811	R 12 (36-2)
		3.782	R140 (34-0)
		3.781	P 53 (30-0)
	18653.585	3.579	P 10 (36-2)
1241	18653.385	3.437	R 13 (36-2)
		3.389	R110 (32-0)
	18653.322		
	18653.118	3.184	P 11 (36-2)
		3.147	P167 (37-0)
		3.113	R161 (36-0)
	18653.033	3.031	R 14 (36-2)
1242	18652.897	2.927	P149 (35-0)
		2.920	R 61 (37-2)
		2.892	P124 (33-0)
	18652.764	2.758	P 12 (36-2)
	18652.597	2.593	R 15 (36-2)
1243	18652.373	2.375	R 57 (30-0)
	18652.311	2.300	P 13 (36-2)
1244	18652.164	2.166	P 54 (30-0)
		2.123	R 16 (36-2)
1245	18652.005	2.027	P 86 (31-0)
		1.995	R 89 (31-0)

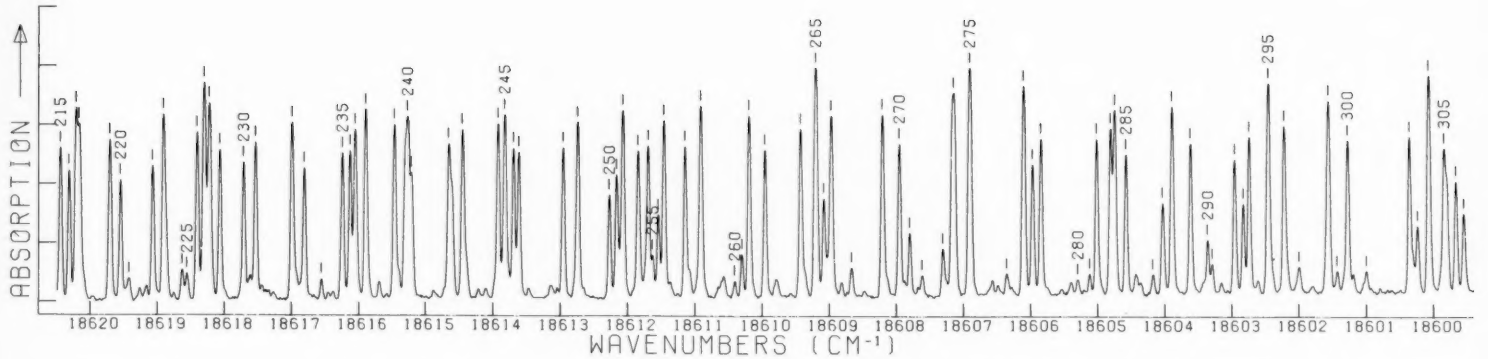
LINE	OBS CM-1	CALC	ASSIGNMENT
	18651.906	1.911	P 59 (37-2)
1246	18651.773	1.810	P 14 (36-2)
		1.776	R127 (33-0)
	18651.624	1.621	R 17 (36-2)
1247	18651.284	1.287	P 15 (36-2)
		1.287	P159 (36-0)
1248	18651.125	1.128	P138 (34-0)
		1.086	R 18 (36-2)
	18650.921	0.922	R 62 (37-2)
1249	18650.732	0.733	R 58 (30-0)
		0.733	P 16 (36-2)
1250	18650.520	0.525	P108 (32-0)
		0.522	P 55 (30-0)
		0.520	R 19 (36-2)
	18650.199	0.204	R152 (35-0)
	18650.154	0.146	P 17 (36-2)
1251	18650.020	0.025	R111 (32-0)
1252	18649.903	9.922	R 20 (36-2)
		9.898	P 60 (37-2)
	18649.530	9.528	P 18 (36-2)
1253	18649.369	9.386	P 87 (31-0)
		9.349	R 90 (31-0)
1254	18649.251	9.291	R 21 (36-2)
		9.251	R141 (34-0)
1255	18649.059	9.061	R 59 (30-0)
1256	18648.848	8.915	P125 (33-0)
		8.890	R 63 (37-2)
		8.878	P 19 (36-2)
		8.848	P 56 (30-0)
1257	18648.626	8.628	R 22 (36-2)
		8.603	R177 (38-0)
	18648.496		
	18648.411	8.418	R170 (37-0)
	18648.316		
	18648.196	8.195	P 20 (36-2)
	18648.063	8.067	P175 (38-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
	18647.905	7.934	R 23 (36-2)
		7.900	P150 (35-0)
1258	18647.850	7.852	P 61 (37-2)
1259	18647.776	7.779	R128 (33-0)
	18647.679		
	18647.590	7.595	R162 (36-0)
	18647.474	7.480	P 21 (36-2)
1260	18647.358	7.360	R 60 (30-0)
1261	18647.141	7.207	R 24 (36-2)
		7.201	P168 (37-0)
		7.146	P 57 (30-0)
		7.141	P109 (32-0)
1262	18646.825	6.825	R 64 (37-2)
1263	18646.681	6.734	P 22 (36-2)
		6.715	P 88 (31-0)
		6.674	R 91 (31-0)
		6.629	R112 (32-0)
		6.590	P139 (34-0)
1264	18646.443	6.448	R 25 (36-2)
1265	18645.957	5.955	P 23 (36-2)
1266	18645.771	5.776	P160 (36-0)
		5.772	P 62 (37-2)
1267	18645.628	5.657	R 26 (36-2)
		5.630	R 61 (30-0)
1268	18645.411	5.413	P 58 (30-0)
1269	18645.139	5.146	P 24 (36-2)
		5.140	R153 (35-0)
1270	18644.900	4.905	P126 (33-0)
1271	18644.827	4.833	R 27 (36-2)
1272	18644.691	4.726	R 65 (37-2)
		4.685	R142 (34-0)
1273	18644.304	4.301	P 25 (36-2)
1274	18643.999	4.013	P 89 (31-0)
		3.978	R 28 (36-2)
		3.967	R 92 (31-0)
1275	18643.867	3.870	R 62 (30-0)

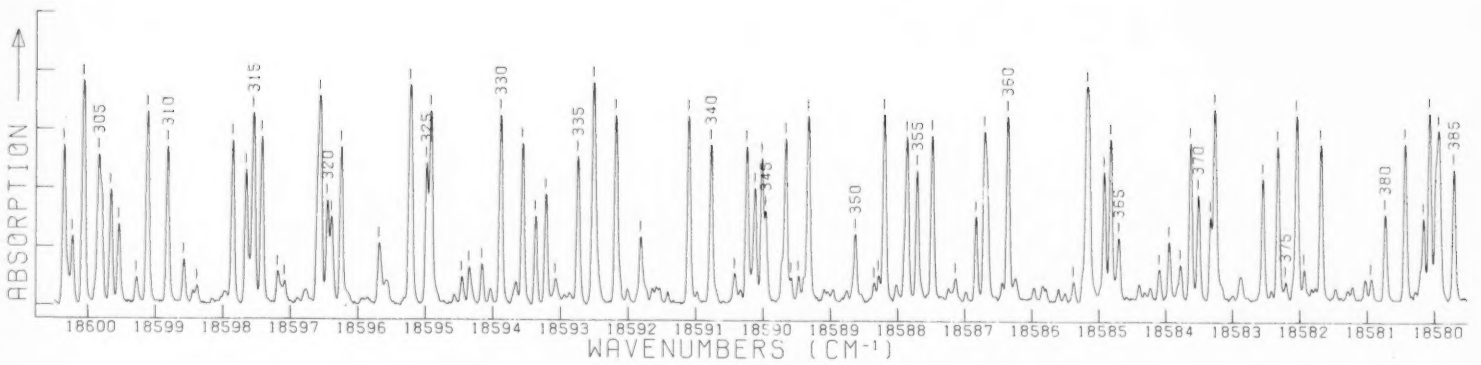
LINE	OBS CM-1	CALC	ASSIGNMENT
1276	18643.727	3.750	R129 (33-0)
		3.725	P110 (32-0)
1277	18643.648	3.659	P 63 (37-2)
		3.652	P 59 (30-0)
1278	18643.425	3.426	P 26 (36-2)
1279	18643.197	3.201	R113 (32-0)
1280	18643.092	3.090	R 29 (36-2)
1281	18642.931		
1282	18642.835	2.836	P151 (35-0)
	18642.711		
	18642.587	2.594	R 66 (37-2)
1283	18642.520	2.519	P 27 (36-2)
	18642.411	2.415	R171 (37-0)
1284	18642.168	2.171	R 30 (36-2)
		2.166	R178 (38-0)
1285	18642.078	2.081	R 63 (30-0)
		2.039	R163 (36-0)
		2.017	P140 (34-0)
1286	18641.858	1.861	P 60 (30-0)
1287	18641.577	1.579	P 28 (36-2)
1288	18641.508	1.513	P 64 (37-2)
1289	18641.229	1.281	P 90 (31-0)
		1.230	R 93 (31-0)
		1.219	R 31 (36-2)
		1.214	P169 (37-0)
1290	18640.858	0.861	P127 (33-0)
1291	18640.608	0.608	P 29 (36-2)
1292	18640.424	0.428	R 67 (37-2)
1293	18640.262	0.277	P111 (32-0)
		0.262	R 64 (30-0)
		0.235	R 32 (36-2)
		0.227	P161 (36-0)
1294	18640.037	0.084	R143 (34-0)
		0.040	P 61 (30-0)
		0.040	R154 (35-0)
1295	18639.736	9.741	R114 (32-0)
1296	18639.687	9.686	R130 (33-0)
	18639.614	9.604	P 30 (36-2)



LINE	OBS CM-1	CALC	ASSIGNMENT
118	18640.428	0.428	R 67 (37-2)
119	18640.266	0.277	P111 (32-0)
		0.262	R 64 (30-0)
		0.235	R 32 (36-2)
		0.227	P161 (36-0)
120	18640.041	0.084	R143 (34-0)
		0.040	P 61 (30-0)
		0.040	R154 (35-0)
121	18639.740	9.741	R114 (32-0)
122	18639.690	9.686	R130 (33-0)
123	18639.612	9.604	P 30 (36-2)
	18639.394		
124	18639.337	9.334	P 65 (37-2)
125	18639.223	9.218	R 33 (36-2)
	18639.055		
	18638.976		
126	18638.517	8.568	P 31 (36-2)
		8.518	P 91 (31-0)
127	18638.416	8.462	R 94 (31-0)
		8.414	R 65 (30-0)
128	18638.192	8.229	R 68 (37-2)
		8.190	P 62 (30-0)
		8.170	R 34 (36-2)
	18638.038		
	18637.939		
	18637.855		
129	18637.730	7.736	P152 (35-0)
130	18637.503	7.500	P 32 (36-2)
131	18637.411	7.409	P191 (34-0)
132	18637.100	7.121	P 66 (37-2)
		7.089	R 35 (36-2)
133	18636.793	6.798	P112 (32-0)
		6.785	P128 (33-0)
134	18636.537	6.536	R 66 (30-0)
	18636.400	6.444	R164 (36-0)
		6.400	P 33 (36-2)
		6.370	R172 (37-0)
135	18636.311	6.311	P 63 (30-0)
136	18636.249	6.249	R115 (32-0)
137	18635.991	5.996	R 69 (37-2)
		5.976	R 36 (36-2)
	18635.811		
138	18635.722	5.725	P 92 (31-0)
139	18635.666	5.663	R 95 (31-0)
140	18635.594	5.589	R131 (33-0)
141	18635.451	5.448	R144 (34-0)
	18635.266	5.268	P 34 (36-2)
	18635.188	5.187	P170 (37-0)
142	18634.882	4.902	R155 (35-0)
		4.874	P 67 (37-2)
		4.830	R 37 (36-2)
143	18634.629	4.640	P162 (36-0)
		4.628	R 67 (30-0)
144	18634.404	4.402	P 64 (30-0)
145	18634.104	4.103	P 35 (36-2)
146	18633.733	3.729	R 70 (37-2)
	18633.652	3.653	R 38 (36-2)
147	18633.286	3.286	P113 (32-0)
	18632.997		
148	18632.901	2.907	P 36 (36-2)
		2.901	P 93 (31-0)
149	18632.838	2.834	R 96 (31-0)
150	18632.692	2.766	P142 (34-0)
		2.725	R116 (32-0)
		2.691	R 68 (30-0)
		2.675	P129 (33-0)
151	18632.599	2.599	P153 (35-0)
		2.594	P 68 (37-2)
152	18632.464	2.464	P 65 (30-0)
		2.443	R 39 (36-2)
	18632.201		
	18631.861		
153	18631.677	1.678	P 37 (36-2)
154	18631.456	1.459	R132 (33-0)
		1.429	R 71 (37-2)
	18631.267		
	18631.197	1.200	R 40 (36-2)
155	18630.725	0.809	R165 (36-0)
		0.777	R145 (34-0)
		0.725	R 69 (30-0)
156	18630.498	0.497	P 66 (30-0)
157	18630.420	0.416	P 38 (36-2)
158	18630.282	0.285	R173 (37-0)
		0.281	P 69 (37-2)
159	18630.045	0.046	P 94 (31-0)
160	18629.974	9.973	R 97 (31-0)
		9.926	R 41 (36-2)
161	18629.740	9.743	P114 (32-0)
		9.728	R156 (35-0)
162	18629.167	9.168	R117 (32-0)
		9.123	P 39 (36-2)
		9.119	P171 (37-0)
		9.096	R 72 (37-2)
163	18629.014	9.014	P163 (36-0)
	18628.811		
164	18628.730	8.729	R 70 (30-0)
165	18628.621	8.619	R 42 (36-2)
166	18628.501	8.531	P130 (33-0)
		8.500	P 67 (30-0)
167	18628.092	8.089	P143 (34-0)
168	18627.935	7.934	P 70 (37-2)
169	18627.799	7.797	P 40 (36-2)
	18627.618		
	18627.424	7.425	P154 (35-0)
170	18627.293	7.294	R133 (33-0)
		7.280	R 43 (36-2)
171	18627.159	7.160	P 95 (31-0)
172	18627.083	7.082	R 98 (31-0)
	18626.870		
173	18626.704	6.728	R 73 (37-2)
		6.703	R 71 (30-0)
174	18626.473	6.509	R 1 (29-0)
		6.499	R 2 (29-0)
		6.491	R 0 (29-0)
		6.473	P 68 (30-0)
		6.460	R 3 (29-0)
		6.439	P 41 (36-2)
175	18626.396	6.392	R 4 (29-0)
		6.371	P 1 (29-0)
176	18626.294	6.296	R 5 (29-0)
		6.267	P 2 (29-0)
177	18626.167	6.172	R 6 (29-0)
		6.167	P115 (32-0)
		6.136	P 3 (29-0)
178	18626.018	6.070	R146 (34-0)
		6.019	R 7 (29-0)
		5.976	P 4 (29-0)
	18625.906	5.908	R 44 (36-2)
179	18625.837	5.838	R 8 (29-0)
180	18625.793	5.788	P 5 (29-0)
181	18625.628	5.629	R 9 (29-0)
182	18625.575	5.579	R118 (32-0)
		5.571	P 6 (29-0)
		5.553	P 71 (37-2)
183	18625.391	5.391	R 10 (29-0)
184	18625.327	5.326	P 7 (29-0)
	18625.211		
185	18625.126	5.136	R166 (36-0)
		5.125	R 11 (29-0)
186	18625.054	5.053	P 8 (29-0)
		5.048	P 42 (36-2)
187	18624.831	4.830	R 12 (29-0)
188	18624.752	4.751	P 9 (29-0)
189	18624.649	4.648	R 72 (30-0)
190	18624.507	4.517	R157 (35-0)
		4.507	R 13 (29-0)
		4.504	R 45 (36-2)
191	18624.417	4.421	P 10 (29-0)
		4.417	P 69 (30-0)
192	18624.360	4.354	P131 (33-0)
		4.327	R 74 (37-2)
193	18624.242	4.246	P 96 (31-0)
194	18624.158	4.160	R 99 (31-0)
		4.159	R174 (37-0)
		4.155	R 14 (29-0)
195	18624.063	4.062	P 11 (29-0)
	18623.931		
196	18623.775	3.775	R 15 (29-0)
197	18623.676	3.675	P 12 (29-0)
		3.626	P 43 (36-2)
198	18623.368	3.376	P144 (34-0)
		3.367	R 16 (29-0)
		3.350	P164 (36-0)
199	18623.260	3.259	P 13 (29-0)
200	18623.095	3.139	P 72 (37-2)
		3.096	R134 (33-0)
		3.068	R 46 (36-2)
CALC	**********	3.011	P172 (37-0)
201	18622.930	2.930	R 17 (29-0)
202	18622.815	2.815	P 14 (29-0)
203	18622.563	2.563	R 73 (30-0)
		2.559	P116 (32-0)
204	18622.465	2.464	R 18 (29-0)
205	18622.336	2.343	P 15 (29-0)
		2.331	P 70 (30-0)
	18622.172	2.214	P155 (35-0)
		2.171	P 44 (36-2)
206	18621.966	1.971	R 19 (29-0)
		1.958	R119 (32-0)
207	18621.842	1.892	R 75 (37-2)
		1.842	P 16 (29-0)
208	18621.598	1.599	R 47 (36-2)
209	18621.449	1.448	R 20 (29-0)
210	18621.305	1.327	R147 (34-0)
		1.313	P 17 (29-0)
		1.297	P 97 (31-0)
211	18621.209	1.206	R100 (31-0)
212	18620.898	0.898	R 21 (29-0)
213	18620.755	0.755	P 18 (29-0)
214	18620.688	0.691	P 73 (37-2)
		0.683	P 45 (36-2)
215	18620.448	0.448	R 74 (30-0)
216	18620.318	0.318	R 22 (29-0)
217	18620.214	0.216	P 71 (30-0)
218	18620.172	0.169	P 19 (29-0)
		0.143	P132 (33-0)
		0.097	R 48 (36-2)
219	18619.712	9.711	R 23 (29-0)
220	18619.554	9.555	P 20 (29-0)
221	18619.426	9.424	R167 (36-0)
		9.423	R 76 (37-2)



LINE	OBS CM-1	CALC	ASSIGNMENT
215	18620.448	0.448	R 74 (30-0)
216	18620.318	0.318	R 22 (29-0)
217	18620.214	0.216	P 71 (30-0)
218	18620.172	0.169	P 19 (29-0)
		0.143	P132 (33-0)
		0.097	R 48 (36-2)
219	18619.712	9.711	R 23 (29-0)
220	18619.554	9.555	P 20 (29-0)
221	18619.426	9.424	R167 (36-0)
		9.423	R 76 (37-2)
	18619.270	9.268	R158 (35-0)
	18619.165	9.164	P 46 (36-2)
222	18619.074	9.075	R 24 (29-0)
223	18618.913	8.919	P117 (32-0)
		8.912	P 21 (29-0)
		8.864	R135 (33-0)
	18618.751		
224	18618.633	8.628	P145 (34-0)
225	18618.561	8.564	R 49 (36-2)
226	18618.411	8.410	R 25 (29-0)
227	18618.307	8.319	P 98 (31-0)
		8.304	R120 (32-0)
		8.303	R 75 (30-0)
228	18618.231	8.240	P 22 (29-0)
		8.222	R101 (31-0)
		8.210	P 74 (37-2)
229	18618.071	8.071	P 72 (30-0)
		7.991	R175 (37-0)
230	18617.717	7.717	R 26 (29-0)
	18617.615	7.647	P165 (36-0)
		7.611	P 47 (36-2)
231	18617.541	7.540	P 23 (29-0)
232	18616.995	6.997	R 50 (36-2)
		6.995	R 27 (29-0)
		6.967	P156 (35-0)
		6.921	R 77 (37-2)
233	18616.812	6.862	P173 (37-0)
		6.812	P 24 (29-0)
234	18616.554	6.549	R148 (34-0)
	18616.450		
	18616.382		
235	18616.246	6.245	R 28 (29-0)
236	18616.131	6.129	R 76 (30-0)
237	18616.054	6.055	P 25 (29-0)
		6.027	P 48 (36-2)
238	18615.898	5.899	P133 (33-0)
		5.897	P 73 (30-0)
	18615.689	5.695	P 75 (37-2)
239	18615.466	5.466	R 29 (29-0)
		5.398	R 51 (36-2)
240	18615.270	5.310	P 99 (31-0)
		5.270	P 26 (29-0)
241	18615.213	5.247	P118 (32-0)
		5.207	R102 (31-0)
242	18614.658	4.659	R 30 (29-0)
		4.618	R121 (32-0)
		4.598	R136 (33-0)
243	18614.456	4.456	P 27 (29-0)
		4.410	P 49 (36-2)
		4.384	R 78 (37-2)
	18614.220		
	18614.111		
244	18613.926	3.982	R159 (35-0)
		3.926	R 77 (30-0)
245	18613.824	3.845	P146 (34-0)
		3.824	R 31 (29-0)
		3.767	R 52 (36-2)
246	18613.693	3.693	P 74 (30-0)
		3.672	R168 (36-0)
247	18613.614	3.614	P 28 (29-0)
	18613.467		
	18613.141	3.146	P 76 (37-2)
	18613.041		
248	18612.959	2.959	R 32 (29-0)
249	18612.743	2.760	P 50 (36-2)
		2.743	P 29 (29-0)
250	18612.270	2.270	P100 (31-0)
251	18612.162	2.161	R103 (31-0)
		2.103	R 53 (36-2)
252	18612.069	2.067	R 33 (29-0)
253	18611.843	1.905	P166 (36-0)
		1.844	P 30 (29-0)
		1.814	R 79 (37-2)
		1.782	R176 (37-0)
254	18611.692	1.736	R149 (34-0)
		1.692	R 78 (30-0)
		1.683	P157 (35-0)
255	18611.627	1.621	P134 (33-0)
256	18611.542	1.543	P119 (32-0)
257	18611.459	1.459	P 75 (30-0)
	18611.362		
258	18611.146	1.145	R 34 (29-0)
		1.079	P 51 (36-2)
259	18610.913	0.916	P 31 (29-0)
		0.900	R122 (32-0)
CALC	*********	0.672	P174 (37-0)
	18610.569	0.564	P 77 (37-2)
260	18610.407	0.407	R 54 (36-2)
261	18610.301	0.298	R137 (33-0)
262	18610.195	0.196	R 35 (29-0)
263	18609.959	9.959	P 32 (29-0)
	18609.785		
264	18609.429	9.428	R 79 (30-0)
		9.364	P 52 (36-2)
265	18609.204	9.217	R 36 (29-0)
		9.210	R 80 (37-2)
		9.200	P101 (31-0)
		9.196	P 76 (30-0)
266	18609.084	9.083	R104 (31-0)
		9.026	P147 (34-0)
267	18608.974	8.975	P 33 (29-0)
	18608.820		
268	18608.671	8.678	R 55 (36-2)
		8.659	R160 (35-0)
269	18608.211	8.210	R 37 (29-0)
270	18607.960	7.961	P 34 (29-0)
		7.947	P 78 (37-2)
		7.881	R169 (36-0)
271	18607.805	7.806	P120 (32-0)
	18607.677		
272	18607.616	7.617	P 53 (36-2)
273	18607.312	7.309	P135 (33-0)
274	18607.150	7.175	R 38 (29-0)
		7.149	R123 (32-0)
		7.135	R 80 (30-0)
275	18606.910	6.919	P 35 (29-0)
		6.916	R 56 (36-2)
		6.903	P 77 (30-0)
		6.887	R150 (34-0)
	18606.573	6.572	R 81 (37-2)
	18606.490		
276	18606.358	6.362	P158 (35-0)
277	18606.107	6.124	P167 (36-0)
		6.110	R 39 (29-0)
		6.098	P102 (31-0)
278	18605.974	5.975	R105 (31-0)
		5.963	R138 (33-0)
279	18605.849	5.849	P 36 (29-0)
		5.838	P 54 (36-2)
CALC	*********	5.531	R177 (37-0)
	18605.396		
280	18605.298	5.297	P 79 (37-2)
281	18605.123	5.122	R 57 (36-2)
282	18605.017	5.018	R 40 (29-0)
283	18604.812	4.812	R 81 (30-0)
284	18604.750	4.750	P 37 (29-0)
285	18604.581	4.580	P 78 (30-0)
	18604.426	4.441	P175 (37-0)
	18604.355		
286	18604.177	4.172	P148 (34-0)
287	18604.035	4.037	P121 (32-0)
		4.026	P 55 (36-2)
288	18603.896	3.899	R 82 (37-2)
		3.896	R 41 (29-0)
289	18603.622	3.623	P 38 (29-0)
290	18603.366	3.365	R124 (32-0)
291	18603.298	3.298	R161 (35-0)
		3.295	R 58 (36-2)
	18603.156		
292	18602.966	2.966	P103 (31-0)
		2.964	P136 (33-0)
293	18602.835	2.835	R106 (31-0)
294	18602.746	2.746	R 42 (29-0)
	18602.616	2.613	P 80 (37-2)
295	18602.463	2.467	P 39 (29-0)
		2.459	R 82 (30-0)
296	18602.228	2.227	P 79 (30-0)
		2.182	P 56 (36-2)
297	18602.004	2.051	R170 (36-0)
		2.002	R151 (34-0)
	18601.792		
298	18601.568	1.595	R139 (33-0)
		1.568	R 43 (29-0)
299	18601.435	1.436	R 59 (36-2)
300	18601.282	1.282	P 40 (29-0)
	18601.195	1.193	R 83 (37-2)
301	18601.005	1.004	P159 (35-0)
302	18600.361	0.360	R 44 (29-0)
		0.305	P 57 (36-2)
		0.304	P168 (36-0)
303	18600.236	0.236	P122 (32-0)
304	18600.071	0.077	R 83 (30-0)
		0.069	P 41 (29-0)
305	18599.844	9.895	P 81 (37-2)
		9.845	P 80 (30-0)
		9.802	P104 (31-0)
306	18599.664	9.664	R107 (31-0)
307	18599.547	9.549	R125 (32-0)
		9.544	R 60 (36-2)



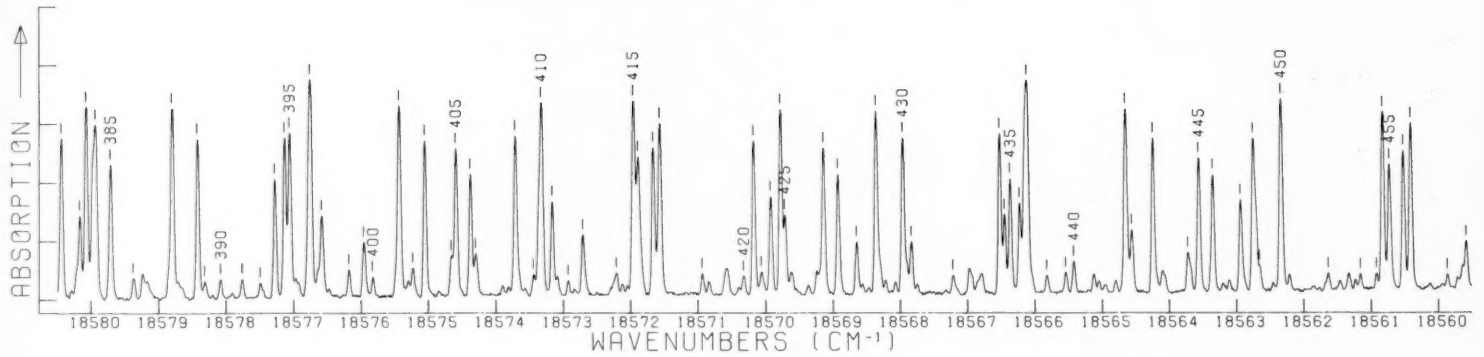
LINE	OBS CM-1	CALC	ASSIGNMENT
302	18600.361	0.360	R 44 (29-0)
		0.305	P 57 (36-2)
		0.304	P168 (36-0)
303	18600.236	0.236	P122 (32-0)
304	18600.071	0.077	R A3 (30-0)
		0.069	P 41 (29-0)
305	18599.844	9.895	P 81 (37-2)
		9.845	P A0 (30-0)
		9.802	P104 (31-0)
306	18599.664	9.664	R107 (31-0)
307	18599.547	9.549	R125 (32-0)
		9.544	R 60 (36-2)
308	18599.288	9.283	P149 (34-0)
309	18599.125	9.124	R 45 (29-0)
310	18598.827	8.827	P 42 (29-0)
311	18598.588	8.585	P137 (33-0)
	18598.453	8.453	R 84 (37-2)
312	18598.394	8.395	P 58 (36-2)
	18598.167	8.169	P176 (37-0)
	18597.975		
313	18597.861	7.900	R162 (35-0)
		7.860	R 46 (29-0)
314	18597.664	7.664	R 84 (30-0)
		7.619	R 61 (36-2)
315	18597.557	7.556	P 43 (29-0)
316	18597.433	7.433	P 81 (30-0)
317	18597.195	7.193	R140 (33-0)
318	18597.094	7.144	P 82 (37-2)
		7.082	R152 (34-0)
	18596.900		
	18596.778		
319	18596.571	6.608	P105 (31-0)
		6.566	R 47 (29-0)
320	18596.460	6.462	R108 (31-0)
		6.453	P 59 (36-2)
321	18596.402	6.402	P123 (32-0)
322	18596.257	6.257	P 44 (29-0)
	18596.182	6.181	R171 (36-0)
	18595.943		
	18595.871	5.866	R 10 (35-2)

LINE	OBS CM-1	CALC	ASSIGNMENT
323	18595.694	5.700	R126 (32-0)
		5.679	R A5 (37-2)
		5.661	R 62 (36-2)
	18595.591	5.608	P160 (35-0)
		5.563	R 11 (35-2)
324	18595.232	5.244	R 4A (29-0)
		5.229	R 12 (35-2)
		5.221	R A5 (30-0)
325	18594.991	4.992	P A2 (30-0)
326	18594.929	4.930	P 45 (29-0)
		4.864	R 13 (35-2)
	18594.581	4.579	P 11 (35-2)
327	18594.471	4.478	P 60 (36-2)
		4.467	R 14 (35-2)
		4.445	P169 (36-0)
328	18594.362	4.359	P150 (34-0)
		4.358	P 83 (37-2)
329	18594.171	4.171	P138 (33-0)
		4.159	P 12 (35-2)
	18594.043	4.039	R 15 (35-2)
330	18593.894	3.894	R 49 (29-0)
	18593.675	3.708	P 13 (35-2)
		3.670	R 63 (36-2)
331	18593.573	3.579	R 16 (35-2)
		3.573	P 46 (29-0)
332	18593.381	3.382	P106 (31-0)
333	18593.228	3.229	R109 (31-0)
		3.226	P 14 (35-2)
334	18593.085	3.088	R 17 (35-2)
	18592.949		
	18592.871	2.870	R A6 (37-2)
335	18592.751	2.756	R141 (33-0)
		2.749	R A6 (30-0)
		2.712	P 15 (35-2)
336	18592.518	2.565	R 18 (35-2)
		2.536	P124 (32-0)
		2.520	P A3 (30-0)
		2.514	R 50 (29-0)
		2.471	P 61 (36-2)
		2.464	R163 (35-0)

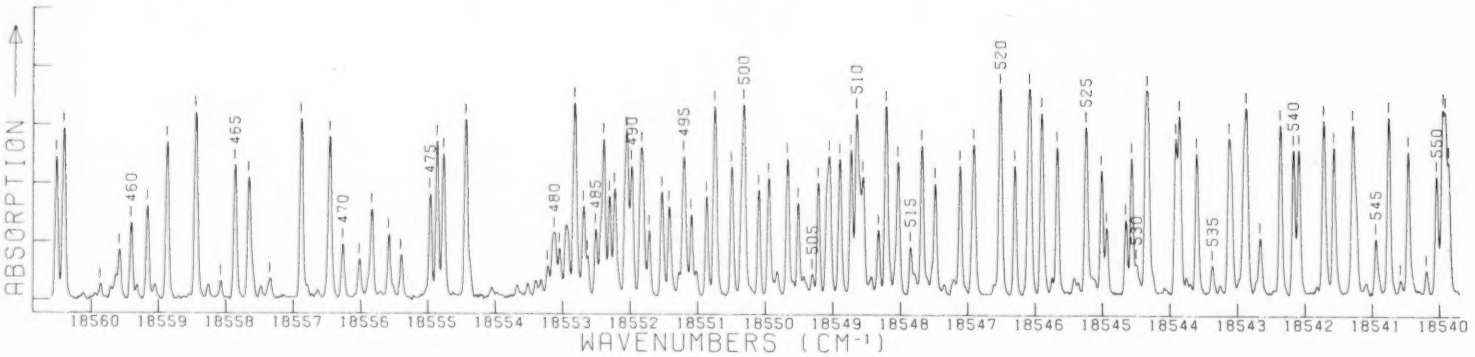
LINE	OBS CM-1	CALC	ASSIGNMENT
337	18592.188	2.188	P 47 (29-0)
		2.167	P 16 (35-2)
		2.125	R153 (34-0)
	18592.012	2.011	R 19 (35-2)
338	18591.819	1.856	P177 (37-0)
		1.819	R127 (32-0)
	18591.644	1.647	R 64 (36-2)
	18591.587	1.590	P 17 (35-2)
	18591.544	1.538	P 84 (37-2)
	18591.425	1.426	R 20 (35-2)
339	18591.106	1.106	R 51 (29-0)
	18590.984	0.982	P 18 (35-2)
340	18590.775	0.809	R 21 (35-2)
		0.775	P 48 (29-0)
341	18590.429	0.430	P 62 (36-2)
	18590.344	0.343	P 19 (35-2)
342	18590.248	0.271	R172 (36-0)
		0.247	R A7 (30-0)
343	18590.125	0.176	P161 (35-0)
		0.160	R 22 (35-2)
		0.126	P107 (31-0)
344	18590.019	0.027	R A7 (37-2)
		0.019	P A4 (30-0)
345	18589.966	9.964	R110 (31-0)
346	18589.669	9.724	P139 (33-0)
		9.672	P 20 (35-2)
		9.669	R 52 (29-0)
347	18589.595	9.591	R 65 (36-2)
348	18589.481	9.481	R 23 (35-2)
	18589.400	9.398	P151 (34-0)
349	18589.333	9.332	P 49 (29-0)
	18589.096		
	18589.048		
	18588.970	8.970	P 21 (35-2)
	18588.769	8.769	R 24 (35-2)
350	18588.638	8.684	P A5 (37-2)
		8.638	P125 (32-0)
	18588.552	8.547	P170 (36-0)
351	18588.358	8.358	P 63 (36-2)

LINE	OBS CM-1	CALC	ASSIGNMENT
352	18588.291	8.286	R142 (33-0)
353	18588.204	8.236	P 22 (35-2)
		8.204	R 53 (29-0)
	18588.022	8.026	R 25 (35-2)
354	18587.863	7.904	R12A (32-0)
		7.861	P 50 (29-0)
355	18587.713	7.714	R A8 (30-0)
356	18587.4A7	7.502	R 66 (36-2)
		7.487	P A5 (30-0)
		7.471	P 23 (35-2)
339	18587.249	7.252	R 26 (35-2)
357	18587.143	7.150	R A8 (37-2)
		7.133	R154 (34-0)
	18586.988	6.990	R164 (35-0)
341	18586.837	6.838	P10A (31-0)
359	18586.707	6.709	R 54 (29-0)
		6.674	P 24 (35-2)
		6.668	R111 (31-0)
	18586.444	6.446	R 27 (35-2)
360	18586.361	6.362	P 51 (29-0)
	18586.246	6.252	P 64 (36-2)
	18585.978		
	18585.844	5.846	P 25 (35-2)
	18585.798	5.797	P A6 (37-2)
	18585.606	5.608	R 28 (35-2)
	18585.506	5.501	P178 (37-0)
361	18585.382	5.381	R 67 (36-2)
362	18585.174	5.243	P140 (33-0)
		5.186	R 55 (29-0)
		5.152	R A9 (30-0)
363	18584.926	4.986	P 26 (35-2)
		4.926	P A6 (30-0)
364	18584.833	4.833	P 52 (29-0)
365	18584.709	4.739	R 29 (35-2)
		4.707	P126 (32-0)
		4.706	P162 (35-0)
	18584.405	4.403	P152 (34-0)
	18584.321	4.322	R173 (36-0)
	18584.240	4.239	R A9 (37-2)

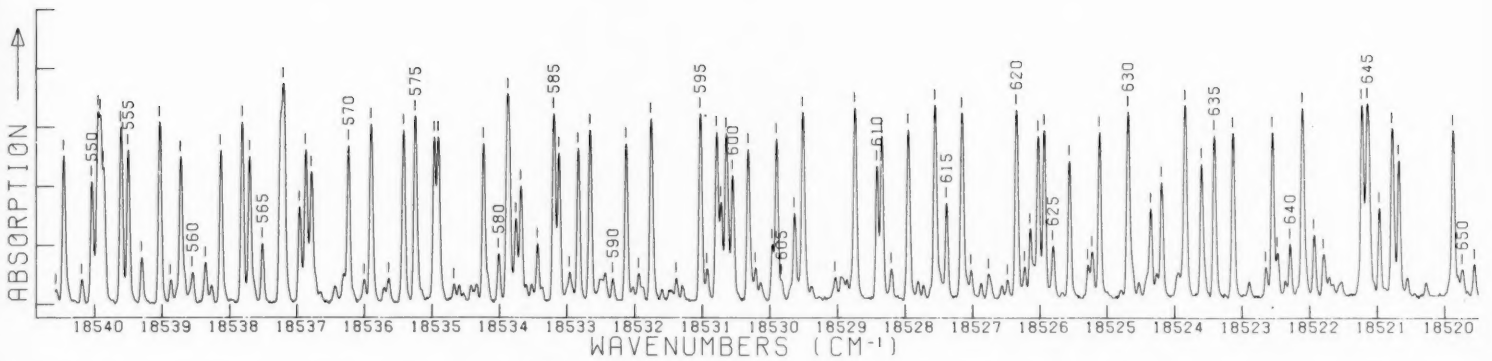
LINE	OBS CM-1	CALC	ASSIGNMENT
366	18584.104	4.114	P 65 (36-2)
		4.095	P 27 (35-2)
367	18583.958	3.957	R129 (32-0)
368	18583.788	3.839	R 30 (35-2)
		3.781	R143 (33-0)
369	18583.634	3.634	R 56 (29-0)
370	18583.518	3.519	P109 (31-0)
371	18583.340	3.341	R112 (31-0)
372	18583.276	3.276	P 53 (29-0)
		3.226	R 68 (36-2)
		3.172	P 28 (35-2)
	18582.891	2.907	R 31 (35-2)
		2.875	P A7 (37-2)
373	18582.560	2.559	R 90 (30-0)
374	18582.334	2.335	P A7 (30-0)
375	18582.221	2.218	P 29 (35-2)
376	18582.053	2.105	R155 (34-0)
		2.054	R 57 (29-0)
377	18581.941	1.943	R 32 (35-2)
		1.942	P 66 (36-2)
378	18581.691	1.691	P 54 (29-0)
	18581.477	1.479	R165 (35-0)
	18581.294	1.294	R 90 (37-2)
	18581.231	1.232	P 30 (35-2)
	18581.038	1.038	R 69 (36-2)
379	18580.949	0.948	R 33 (35-2)
380	18580.739	0.743	P127 (32-0)
		0.728	P141 (33-0)
381	18580.445	0.444	R 58 (29-0)
382	18580.169	0.215	P 31 (35-2)
		0.169	P110 (31-0)
383	18580.076	0.076	P 55 (29-0)
384	18579.938	9.982	R113 (31-0)
		9.977	R130 (32-0)
		9.937	R 91 (30-0)
		9.921	R 34 (35-2)
		9.919	P A8 (37-2)
385	18579.714	9.738	P 67 (36-2)
		9.714	P A8 (30-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
381	18580.445	0.444	R 58 (29-0)
382	18580.169	0.215	P 31 (35-2)
		0.169	P110 (31-0)
383	18580.076	0.076	P 55 (29-0)
384	18579.938	9.982	R113 (31-0)
		9.977	R130 (32-0)
		9.937	R 91 (30-0)
		9.921	R 34 (35-2)
		9.919	P 88 (37-2)
385	18579.714	9.738	P 67 (36-2)
		9.714	P 88 (30-0)
386	18579.377	9.371	P153 (34-0)
	18579.240	9.241	R144 (33-0)
	18579.176	9.198	P163 (35-0)
		9.166	P 32 (35-2)
387	18578.806	8.862	R 35 (35-2)
		8.818	R 70 (36-2)
		8.806	R 59 (29-0)
388	18578.432	8.433	P 56 (29-0)
389	18578.321	8.333	R174 (36-0)
		8.314	R 91 (37-2)
390	18578.084	8.086	P 33 (35-2)
391	18577.766	7.772	R 36 (35-2)
392	18577.497	7.502	P 68 (36-2)
393	18577.283	7.284	R 92 (30-0)
394	18577.137	7.138	R 60 (29-0)
395	18577.062	7.064	P 89 (30-0)
		7.040	R156 (34-0)
	18576.969	6.974	P 34 (35-2)
	18576.934	6.929	P 89 (37-2)
396	18576.764	6.787	P111 (31-0)
		6.761	P 57 (29-0)
		6.747	P128 (32-0)
397	18576.590	6.650	R 37 (35-2)
		6.592	R114 (31-0)
		6.564	R 71 (36-2)
398	18576.181	6.179	P142 (33-0)
399	18575.963	5.964	R131 (32-0)
		5.929	R166 (35-0)
400	18575.829	5.830	P 35 (35-2)
401	18575.442	5.497	R 38 (35-2)
		5.442	R 61 (29-0)
	18575.305	5.300	R 92 (37-2)
402	18575.235	5.232	P 69 (36-2)
403	18575.060	5.060	P 58 (29-0)
404	18574.665	4.667	R145 (33-0)
		4.655	P 36 (35-2)
405	18574.601	4.601	R 93 (30-0)
406	18574.383	4.383	P 90 (30-0)
407	18574.305	4.312	R 39 (35-2)
		4.304	P154 (34-0)
		4.278	R 72 (36-2)
	18573.904	3.904	P 90 (37-2)
	18573.820		
408	18573.718	3.717	R 62 (29-0)
		3.654	P164 (35-0)
409	18573.445	3.448	P 37 (35-2)
410	18573.331	3.375	P112 (31-0)
		3.330	P 59 (29-0)
411	18573.170	3.171	R115 (31-0)
	18573.093	3.095	R 40 (35-2)
412	18572.931	2.930	P 70 (36-2)
413	18572.717	2.718	P129 (32-0)
414	18572.213	2.304	R175 (36-0)
		2.251	R 93 (37-2)
		2.210	P 38 (35-2)
	18572.127		
	18572.050		
415	18571.961	1.963	R 63 (29-0)
		1.959	R 73 (36-2)
		1.940	R157 (34-0)
416	18571.892	1.919	R132 (32-0)
		1.888	R 94 (30-0)
		1.867	R 41 (35-2)
417	18571.672	1.672	P 91 (30-0)
418	18571.574	1.595	P143 (33-0)
		1.572	P 60 (29-0)
419	18570.941	0.940	P 39 (35-2)
	18570.845	0.846	P 91 (37-2)
	18570.583	0.594	P 71 (36-2)
		0.566	R 42 (35-2)
	18570.401		
420	18570.331	0.342	R167 (35-0)
421	18570.181	0.181	R 64 (29-0)
422	18570.066	0.059	R146 (33-0)
423	18569.930	9.931	P113 (31-0)
424	18569.784	9.784	P 61 (29-0)
425	18569.719	9.718	R116 (31-0)
	18569.624	9.638	P 40 (35-2)
		9.606	R 74 (36-2)
	18569.376		
CALC	**********	9.255	R 43 (35-2)
CALC	**********	9.201	P155 (34-0)
426	18569.146	9.168	R 94 (37-2)
		9.145	R 95 (30-0)
427	18568.932	8.931	P 92 (30-0)
428	18568.654	8.656	P130 (32-0)
	18568.569		
	18568.471		
429	18568.368	8.369	R 65 (29-0)
		8.305	P 41 (35-2)
	18568.227	8.226	P 72 (36-2)
	18568.076	8.071	P165 (35-0)
430	18567.969	7.968	P 62 (29-0)
		7.911	R 44 (35-2)
431	18567.841	7.840	R133 (32-0)
	18567.751	7.753	P 92 (37-2)
432	18567.222	7.221	R 75 (36-2)
	18566.976	6.977	P144 (33-0)
		6.940	P 42 (35-2)
	18566.800	6.803	R158 (34-0)
433	18566.529	6.535	R 45 (35-2)
		6.528	R 66 (29-0)
434	18566.456	6.456	P114 (31-0)
435	18566.373	6.372	R 96 (30-0)
436	18566.233	6.234	R176 (36-0)
		6.233	R117 (31-0)
437	18566.130	6.160	P 93 (30-0)
		6.123	P 63 (29-0)
		6.050	R 95 (37-2)
438	18565.825	5.825	P 73 (36-2)
439	18565.542	5.543	P 43 (35-2)
440	18565.425	5.416	R147 (33-0)
	18565.126	5.128	R 46 (35-2)
	18565.051		
	18564.963		
	18564.803	4.802	R 76 (36-2)
441	18564.658	4.717	R168 (35-0)
		4.658	R 67 (29-0)
		4.626	P 93 (37-2)
442	18564.563	4.562	P131 (32-0)
443	18564.250	4.250	P 64 (29-0)
	18564.107	4.115	P 44 (35-2)
		4.062	P156 (34-0)
444	18563.726	3.728	R134 (32-0)
		3.689	R 47 (35-2)
445	18563.568	3.568	R 97 (30-0)
446	18563.360	3.390	P 74 (36-2)
		3.359	P 94 (30-0)
	18563.207		
	18563.114		
447	18562.948	2.949	P115 (31-0)
		2.898	R 96 (37-2)
448	18562.760	2.760	R 68 (29-0)
		2.717	R118 (31-0)
449	18562.661	2.655	P 45 (35-2)
	18562.455	2.451	P166 (35-0)
450	18562.345	2.350	R 77 (36-2)
		2.347	P 65 (29-0)
		2.326	P145 (33-0)
	18562.216	2.219	R 48 (35-2)
451	18561.640	1.630	R159 (34-0)
	18561.463	1.464	P 94 (37-2)
	18561.333		
	18561.235		
452	18561.163	1.163	P 46 (35-2)
453	18560.924	0.923	P 75 (36-2)
454	18560.832	0.832	R 69 (29-0)
455	18560.733	0.738	R148 (33-0)
		0.734	R 98 (30-0)
		0.716	R 49 (35-2)
456	18560.529	0.528	P 95 (30-0)
457	18560.419	0.434	P132 (32-0)
		0.415	P 66 (29-0)
	18560.125	0.125	R177 (36-0)
458	18559.868	9.865	R 78 (36-2)
	18559.710	9.712	R 97 (37-2)
		9.640	P 47 (35-2)
459	18559.585	9.583	R135 (32-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
456	18560.529	0.528	P 95 (30-0)
457	18560.419	0.434	P132 (32-0)
		0.415	P 66 (29-0)
	18560.125	0.125	R177 (36-0)
458	18559.868	9.865	R 78 (36-2)
	18559.710	9.712	R 97 (37-2)
		9.640	P 47 (35-2)
459	18559.585	9.583	R135 (32-0)
460	18559.411	9.411	P116 (31-0)
	18559.327		
461	18559.169	9.182	R 50 (35-2)
		9.169	R119 (31-0)
	18559.056	9.054	R169 (35-0)
462	18558.877	8.887	P157 (34-0)
		8.875	R 70 (29-0)
463	18558.454	8.455	P 67 (29-0)
		8.423	P 76 (36-2)
	18558.270	8.268	P 95 (37-2)
464	18558.083	8.085	P 48 (35-2)
465	18557.871	7.870	R 99 (30-0)
466	18557.665	7.667	P 96 (30-0)
		7.639	P146 (33-0)
		7.615	R 51 (35-2)
	18557.489		
467	18557.353	7.347	R 79 (36-2)
468	18556.890	6.890	R 71 (29-0)
	18556.799	6.793	P167 (35-0)
	18556.638		
469	18556.467	6.498	P 49 (35-2)
		6.490	R 98 (37-2)
		6.465	P 68 (29-0)
		6.421	R160 (34-0)
470	18556.271	6.274	P133 (32-0)
471	18556.023	6.026	R149 (33-0)
		6.017	R 52 (35-2)
472	18555.840	5.889	P 77 (36-2)
		5.841	P117 (31-0)
	18555.718		
473	18555.586	5.589	R120 (31-0)
474	18555.407	5.405	R136 (32-0)
475	18554.977	5.038	P 96 (37-2)
		4.976	R100 (30-0)
476	18554.875	4.879	P 50 (35-2)
		4.875	R 72 (29-0)
477	18554.776	4.795	R 80 (36-2)
		4.776	P 97 (30-0)
478	18554.447	4.447	P 69 (29-0)
		4.387	R 53 (35-2)
	18554.055		
	18553.974	3.975	R178 (36-0)
	18553.681	3.677	P158 (34-0)
	18553.526		
	18553.409		
	18553.331	3.323	P 78 (36-2)
479	18553.230	3.234	R 99 (37-2)
		3.228	P 51 (35-2)
480	18553.131	3.165	R 1 (28-0)
		3.156	R 2 (28-0)
		3.147	R 0 (28-0)
		3.119	R 3 (28-0)
481	18553.056	3.055	R 4 (28-0)
		3.025	P 1 (28-0)
	18552.939	2.962	R 5 (28-0)
		2.923	P 2 (28-0)
		2.918	P147 (33-0)
482	18552.832	2.842	R 6 (28-0)
		2.831	R 73 (29-0)
		2.792	P 3 (28-0)
483	18552.696	2.725	R 54 (35-2)
		2.693	R 7 (28-0)
484	18552.640	2.634	P 4 (28-0)
485	18552.517	2.517	R 8 (28-0)
486	18552.400	2.448	P 5 (28-0)
		2.399	P 70 (29-0)
487	18552.313	2.313	R 9 (28-0)
488	18552.233	2.240	P118 (31-0)
		2.234	P 6 (28-0)
		2.211	R A1 (36-2)
	18552.060	2.081	P134 (32-0)
		2.081	R 10 (28-0)
		2.051	R101 (30-0)
490	18551.984	1.992	P 7 (28-0)
		1.976	R121 (31-0)
491	18551.836	1.854	P 98 (30-0)
		1.821	R 11 (28-0)
		1.773	P 97 (37-2)
492	18551.723	1.722	P A (28-0)
493	18551.534	1.546	P 52 (35-2)
		1.533	R 12 (28-0)
494	18551.425	1.425	P 9 (28-0)
	18551.284	1.279	R150 (33-0)
495	18551.211	1.217	R 13 (28-0)
		1.194	R137 (32-0)
		1.175	R161 (34-0)
		1.099	P 10 (28-0)
		1.098	P168 (35-0)
496	18551.099	1.031	R 55 (35-2)
	18551.029	0.874	R 14 (28-0)
497	18550.873	0.758	R 74 (29-0)
498	18550.752	0.746	P 11 (28-0)
		0.723	P 79 (36-2)
499	18550.502	0.502	R 15 (28-0)
500	18550.325	0.365	P 12 (28-0)
		0.323	P 71 (29-0)
501	18550.102	0.103	R 16 (28-0)
502	18549.954	9.955	P 13 (28-0)
		9.943	R100 (37-2)
	18549.831	9.831	P 53 (35-2)
503	18549.674	9.675	R 17 (28-0)
	18549.595	9.593	R A2 (36-2)
504	18549.518	9.518	P 14 (28-0)
	18549.433		
505	18549.310	9.305	R 56 (35-2)
506	18549.221	9.220	R 18 (28-0)
507	18549.058	9.096	R102 (30-0)
		9.053	P 15 (28-0)
508	18548.902	8.902	P 99 (30-0)
509	18548.736	8.737	R 19 (28-0)
510	18548.655	8.656	R 75 (29-0)
		8.608	P119 (31-0)
511	18548.563	8.561	P 16 (28-0)
	18548.442	8.474	P 98 (37-2)
		8.430	P159 (34-0)
512	18548.333	8.335	R122 (31-0)
513	18548.220	8.226	R 20 (28-0)
		8.218	P 72 (29-0)
		8.163	P148 (33-0)
514	18548.040	8.091	P A0 (36-2)
		8.085	P 54 (35-2)
		8.040	P 17 (28-0)
515	18547.857	7.855	P135 (32-0)
	18547.792		
516	18547.687	7.687	R 21 (28-0)
517	18547.491	7.547	R 57 (35-2)
		7.491	P 18 (28-0)
	18547.357		
	18547.216		
518	18547.120	7.120	R 22 (28-0)
519	18546.916	6.950	R138 (32-0)
		6.942	R A3 (36-2)
		6.915	P 19 (28-0)
520	18546.524	6.618	R101 (37-2)
		6.525	R 76 (29-0)
		6.525	R 23 (28-0)
		6.497	R151 (33-0)
521	18546.309	6.310	P 20 (28-0)
		6.307	P 55 (35-2)
522	18546.089	6.110	R103 (30-0)
		6.083	P 73 (29-0)
523	18545.907	5.920	P100 (30-0)
		5.902	R 24 (28-0)
		5.892	R162 (34-0)
	18545.754	5.758	R 58 (35-2)
524	18545.677	5.678	P 21 (28-0)
	18545.423	5.425	P A1 (36-2)
	18545.368	5.364	P169 (35-0)
525	18545.251	5.251	R 25 (28-0)
	18545.138	5.140	P 99 (37-2)
526	18545.018	5.018	P 22 (28-0)
527	18544.942	4.944	P120 (31-0)
528	18544.659	4.660	R123 (31-0)
529	18544.572	4.573	R 26 (28-0)
530	18544.502	4.497	P 56 (35-2)
531	18544.346	4.365	R 77 (29-0)
		4.329	P 23 (28-0)
		4.257	R A4 (36-2)
		3.936	R 59 (35-2)
532	18543.919	3.920	P 74 (29-0)
		3.866	R 27 (28-0)
533	18543.867	3.760	R 27 (31-1)
	18543.761		
	18543.703		
534	18543.610	3.613	P 24 (28-0)
		3.596	R136 (32-0)
535	18543.376	3.374	P149 (33-0)
	18543.259	3.258	R102 (37-2)
536	18543.128	3.147	P160 (34-0)
		3.131	R 28 (28-0)
		3.094	R104 (30-0)
537	18542.876	2.985	R 28 (31-1)
		2.908	P101 (30-0)
		2.869	P 25 (28-0)
538	18542.669	2.726	P A2 (36-2)
		2.672	R139 (32-0)
		2.655	P 57 (35-2)
539	18542.367	2.369	R 29 (28-0)
540	18542.175	2.180	R 29 (31-1)
		2.175	R 78 (29-0)
541	18542.096	2.097	P 26 (28-0)
		2.082	R 60 (35-2)
542	18541.728	1.771	P100 (37-2)
		1.727	P 75 (29-0)
		1.680	R152 (33-0)
543	18541.578	1.578	R 30 (28-0)
		1.539	R A5 (36-2)
544	18541.295	1.345	R 30 (31-1)
		1.297	P 27 (28-0)
		1.248	P121 (31-0)
	18541.100		
545	18540.951	0.953	R124 (31-0)
546	18540.760	0.781	P 58 (35-2)
		0.760	R 31 (28-0)
547	18540.583	0.573	R163 (34-0)
548	18540.471	0.481	R 31 (31-1)
		0.469	P 28 (28-0)
549	18540.197	0.196	R 61 (35-2)
550	18540.047	0.048	R105 (30-0)
551	18539.951	9.993	P A3 (36-2)
		9.957	R 79 (29-0)
552	18539.920	9.913	R 32 (28-0)
553	18539.872	9.866	R102 (30-0)
		9.862	R103 (37-2)



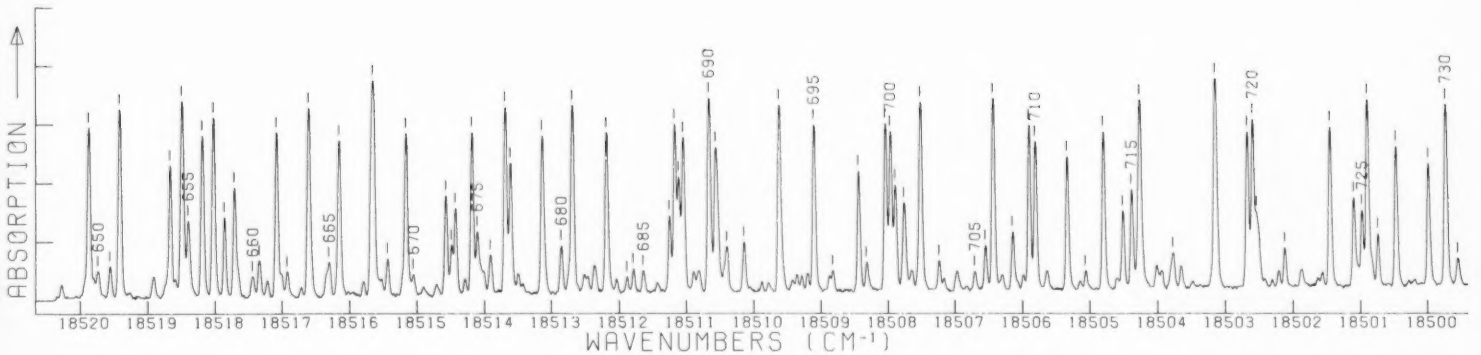
LINE	OBS CM-1	CALC	ASSIGNMENT
547	18540.583	0.573	R163 (34-0)
548	18540.471	0.481	R 31 (31-1)
		0.469	P 28 (28-0)
549	18540.197	0.196	R 61 (35-2)
550	18540.047	0.048	R105 (30-0)
551	18539.951	9.993	P 83 (36-2)
		9.957	R 79 (29-0)
552	18539.920	9.913	R 32 (28-0)
553	18539.872	9.866	P102 (30-0)
		9.862	R103 (37-2)
554	18539.612	9.614	P 29 (28-0)
		9.592	P170 (35-0)
		9.588	R 32 (31-1)
555	18539.506	9.506	P 76 (29-0)
556	18539.306	9.304	P137 (32-0)
557	18539.038	9.038	R 33 (28-0)
558	18538.875	8.876	P 59 (35-2)
559	18538.728	8.788	R 86 (36-2)
		8.730	P 30 (28-0)
		8.665	R 33 (31-1)
560	18538.557	8.549	P150 (33-0)
561	18538.364	8.368	P101 (37-2)
		8.361	R140 (32-0)
	18538.275	8.278	R 62 (35-2)
562	18538.137	8.136	R 34 (28-0)
563	18537.818	7.827	P161 (34-0)
		7.818	P 31 (28-0)
564	18537.709	7.713	R 34 (31-1)
		7.709	R 80 (29-0)
565	18537.519	7.521	P122 (31-0)
566	18537.210	7.255	P 77 (29-0)
		7.228	P 84 (36-2)
		7.215	R125 (31-0)
		7.205	R 35 (28-0)
567	18536.970	6.971	R106 (30-0)
		6.938	P 60 (35-2)
568	18536.879	6.878	P 32 (28-0)
569	18536.794	6.828	R153 (33-0)
		6.793	P103 (30-0)
		6.731	R 35 (31-1)
	18536.660		
	18536.443	6.432	R104 (37-2)
	18536.319	6.328	R 63 (35-2)

LINE	OBS CM-1	CALC	ASSIGNMENT
570	18536.247	6.247	R 36 (28-0)
571	18536.010	6.003	R 87 (36-2)
572	18535.910	5.910	P 33 (28-0)
	18535.714	5.720	R 36 (31-1)
573	18535.646		
574	18535.432	5.432	R 81 (29-0)
575	18535.259	5.260	R 37 (28-0)
		5.218	R164 (34-0)
576	18534.975	4.979	P138 (32-0)
		4.975	P 78 (29-0)
		4.968	P 61 (35-2)
577	18534.916	4.930	P102 (37-2)
		4.915	P 34 (28-0)
578	18534.680	4.680	R 37 (31-1)
	18534.604	4.603	P 34 (31-1)
	18534.541		
	18534.428	4.429	P 85 (36-2)
	18534.347	4.346	R 64 (35-2)
579	18534.246	4.245	R 38 (28-0)
580	18534.020	4.016	R141 (32-0)
581	18533.883	3.891	P 35 (28-0)
		3.864	R107 (30-0)
582	18533.762	3.783	P171 (35-0)
		3.762	P123 (31-0)
583	18533.689	3.690	P151 (33-0)
		3.690	P104 (30-0)
	18533.611	3.610	R 38 (31-1)
	18533.532	3.532	P 35 (31-1)
584	18533.443	3.444	R126 (31-0)
	18533.375		
585	18533.203	3.202	R 39 (28-0)
		3.185	R 88 (36-2)
586	18533.126	3.126	R 82 (29-0)
587	18532.968	2.967	R105 (37-2)
		2.966	P 62 (35-2)
588	18532.840	2.839	P 36 (28-0)
589	18532.666	2.667	P 79 (29-0)
	18532.506	2.510	R 39 (31-1)
	18532.446	2.471	P162 (34-0)
		2.431	P 36 (31-1)
590	18532.328	2.331	R 65 (35-2)
591	18532.132	2.132	R 40 (28-0)
	18532.030	2.026	P 15 (34-2)

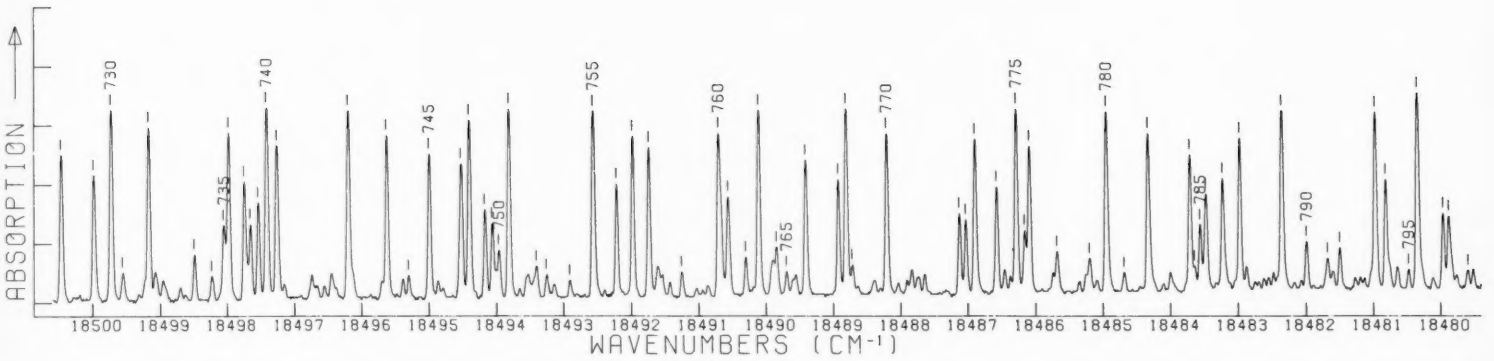
LINE	OBS CM-1	CALC	ASSIGNMENT
592	18531.945	1.941	R154 (33-0)
	18531.890		
593	18531.759	1.760	P 37 (28-0)
	18531.598	1.597	P 86 (36-2)
	18531.461	1.490	P 16 (34-2)
		1.457	P103 (37-2)
594	18531.385	1.381	R 40 (31-1)
	18531.300	1.301	P 37 (31-1)
595	18531.032	1.033	R 41 (28-0)
596	18530.935	0.933	P 63 (35-2)
		0.923	P 17 (34-2)
597	18530.791	0.790	R 83 (29-0)
598	18530.728	0.726	R108 (30-0)
599	18530.650	0.652	P 38 (28-0)
		0.621	P139 (32-0)
600	18530.556	0.556	P105 (30-0)
601	18530.328	0.333	R 89 (36-2)
		0.329	P 80 (29-0)
		0.326	P 18 (34-2)
		0.285	R 66 (35-2)
602	18530.220	0.222	R 41 (31-1)
	18530.147	0.141	P 38 (31-1)
603	18529.970	9.971	P124 (31-0)
604	18529.906	9.906	R 42 (28-0)
605	18529.834	9.825	R165 (34-0)
606	18529.641	9.697	P 19 (34-2)
		9.642	R127 (31-0)
		9.639	R142 (32-0)
607	18529.516	9.516	P 39 (28-0)
		9.467	R106 (37-2)
	18529.386		
608	18529.039	9.038	P 20 (34-2)
		9.034	R 42 (31-1)
	18528.941	8.952	P 39 (31-1)
	18528.870	8.867	P 64 (35-2)
609	18528.750	8.797	P152 (33-0)
		8.751	R 43 (28-0)
		8.731	P 87 (36-2)
610	18528.425	8.425	R 84 (29-0)
611	18528.353	8.352	P 40 (28-0)
		8.348	P 21 (34-2)
612	18528.211	8.206	R 67 (35-2)

LINE	OBS CM-1	CALC	ASSIGNMENT
613	18527.961	7.961	P 81 (29-0)
		7.949	P104 (37-2)
		7.935	P172 (35-0)
	18527.816	7.817	R 43 (31-1)
	18527.734	7.733	P 40 (31-1)
614	18527.563	7.627	P 22 (34-2)
		7.567	R 44 (28-0)
		7.557	R109 (30-0)
		7.447	R 90 (36-2)
615	18527.392	7.392	P106 (30-0)
616	18527.162	7.161	P 41 (28-0)
		7.079	P163 (34-0)
617	18527.027	7.019	R155 (33-0)
	18526.878	6.875	P 23 (34-2)
618	18526.765	6.769	P 65 (35-2)
	18526.571	6.570	R 44 (31-1)
619	18526.487	6.485	P 41 (31-1)
620	18526.355	6.356	R 45 (28-0)
621	18526.232	6.230	P140 (32-0)
622	18526.149	6.149	P125 (31-0)
		6.095	R 68 (35-2)
		6.092	P 24 (34-2)
	18526.031	6.031	R 85 (29-0)
623	18525.941	5.941	P 42 (28-0)
624		5.931	R107 (37-2)
	18525.810	5.832	P 88 (36-2)
625		5.808	R128 (31-0)
	18525.565	5.565	P 82 (29-0)
626	18525.289	5.293	R 45 (31-1)
627		5.279	P 25 (34-2)
	18525.226	5.227	R143 (32-0)
628		5.207	P 42 (31-1)
	18525.117	5.117	R 46 (28-0)
629	18524.792		
	18524.693	4.693	P 43 (28-0)
630		4.639	P 66 (35-2)
	18524.529	4.528	R 91 (36-2)
631	18524.357	4.434	P 26 (34-2)
		4.407	P105 (37-2)
		4.396	R166 (34-0)
		4.358	R110 (30-0)
	18524.269		
632	18524.196	4.197	P107 (30-0)
	18523.954	3.987	R 46 (31-1)
		3.952	R 69 (35-2)

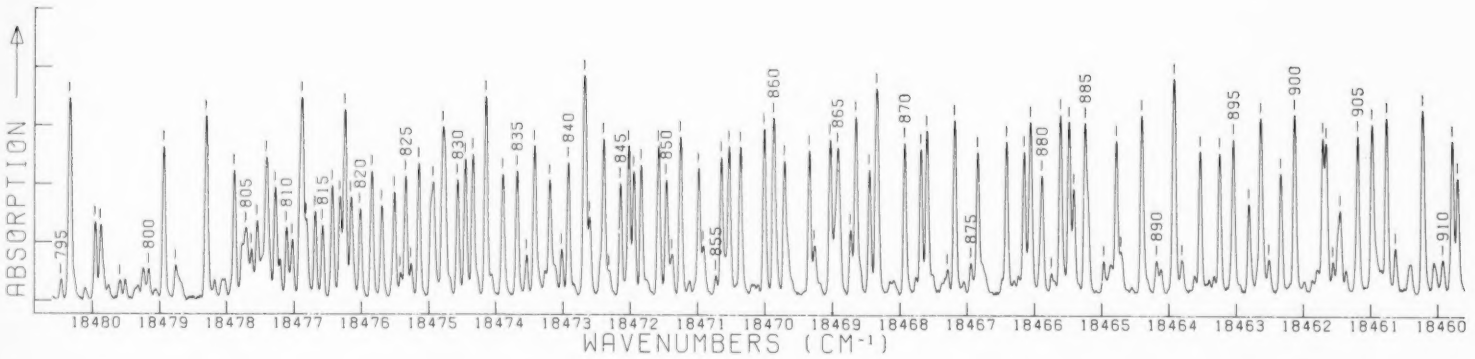
LINE	OBS CM-1	CALC	ASSIGNMENT
633	18523.850	3.900	P 43 (31-1)
		3.868	P153 (33-0)
		3.849	R 47 (28-0)
634	18523.607	3.607	R 86 (29-0)
		3.559	P 27 (34-2)
635	18523.417	3.417	P 44 (28-0)
636	18523.139	3.139	P 83 (29-0)
	18522.902	2.899	P 89 (36-2)
637	18522.653	2.653	P 28 (34-2)
		2.651	R 47 (31-1)
638	18522.553	2.564	P 44 (31-1)
		2.554	R 48 (28-0)
639	18522.479	2.476	P 67 (35-2)
	18522.366	2.361	R108 (37-2)
640	18522.294	2.294	P126 (31-0)
641	18522.112	2.113	P 45 (28-0)
		2.062	R156 (33-0)
		2.048	P173 (35-0)
642	18521.939	1.941	R129 (31-0)
643	18521.800	1.805	P141 (32-0)
		1.776	R 70 (35-2)
		1.716	P 29 (34-2)
	18521.660	1.651	P164 (34-0)
	18521.539	1.576	R 92 (36-2)
644	18521.229	1.286	R 48 (31-1)
		1.230	R 49 (28-0)
645	18521.147	1.197	P 45 (31-1)
		1.154	R 87 (29-0)
		1.128	R111 (30-0)
646	18520.972	0.973	P108 (30-0)
647	18520.781	0.829	P106 (37-2)
		0.782	R144 (32-0)
		0.780	P 46 (28-0)
		0.747	P 30 (34-2)
648	18520.685	0.684	P 84 (29-0)
	18520.560	0.558	R 33 (34-2)
	18520.282	0.282	P 68 (35-2)
649	18519.879	9.934	P 90 (36-2)
		9.890	R 49 (31-1)
		9.878	R 50 (28-0)
		9.802	P 46 (31-1)
650	18519.743	9.748	P 31 (34-2)
651	18519.565	9.568	R 71 (35-2)
		9.553	R 34 (34-2)



LINE	OBS CM-1	CALC	ASSIGNMENT
	18520.282	0.282	P 68 (35-2)
649	18519.879	9.934	P 90 (36-2)
		9.890	R 49 (31-1)
		9.878	R 50 (28-0)
		9.802	P 46 (31-1)
650	18519.743	9.748	P 31 (34-2)
651	18519.565	9.568	R 71 (35-2)
		9.553	R 34 (34-2)
652	18519.419	9.420	P 47 (28-0)
	18518.918	8.930	R167 (34-0)
		8.905	P154 (33-0)
653	18518.672	8.756	R109 (37-2)
		8.719	P 32 (34-2)
		8.672	R 88 (29-0)
	18518.590	8.590	R 93 (36-2)
654	18518.499	8.516	R 35 (34-2)
		8.498	R 51 (28-0)
		8.466	R 50 (31-1)
655	18518.407	8.408	P127 (31-0)
		8.376	P 47 (31-1)
656	18518.200	8.200	P 85 (29-0)
657	18518.033	8.055	P 69 (35-2)
		8.042	R130 (31-0)
		8.032	P 48 (28-0)
658	18517.865	7.867	R112 (30-0)
659	18517.716	7.717	P109 (30-0)
		7.656	P 33 (34-2)
660	18517.442	7.449	R 36 (34-2)
661	18517.343	7.347	P142 (32-0)
		7.328	R 72 (35-2)
	18517.221	7.217	P107 (37-2)
662	18517.089	7.089	R 52 (28-0)
		7.070	R157 (33-0)
	18517.011	7.012	R 51 (31-1)
663	18516.929	6.934	P 91 (36-2)
		6.922	P 48 (31-1)
	18516.725		
664	18516.614	6.615	P 49 (28-0)
		6.566	P 34 (34-2)
665	18516.310	6.350	R 37 (34-2)
		6.303	R145 (32-0)
666	18516.160	6.186	P165 (34-0)
		6.160	R 89 (29-0)
	18515.796	5.797	P 70 (35-2)
667	18515.658	5.687	P 86 (29-0)
		5.653	R 53 (28-0)
		5.570	R 94 (36-2)
	18515.532	5.528	R 52.(31-1)
668	18515.441	5.443	P 35 (34-2)
		5.437	P 49 (31-1)
669	18515.171	5.221	R 38 (34-2)
		5.170	P 50 (28-0)
		5.115	R110 (37-2)
670	18515.059	5.056	R 73 (35-2)
	18514.907		
	18514.704		
671	18514.574	4.576	R113 (30-0)
672	18514.489	4.490	P128 (31-0)
673	18514.430	4.431	P110 (30-0)
	18514.290	4.290	P 36 (34-2)
674	18514.188	4.186	R 54 (28-0)
675	18514.110	4.112	R131 (31-0)
		4.060	R 39 (34-2)
		4.014	R 53 (31-1)
676	18513.915	3.923	P 50 (31-1)
		3.907	P155 (33-0)
		3.901	P 92 (36-2)
677	18513.698	3.698	P 51 (28-0)
678	18513.619	3.619	R 90 (29-0)
		3.569	P108 (37-2)
	18513.504	3.506	P 71 (35-2)
	18513.436	3.426	R168 (34-0)
679	18513.143	3.144	P 87 (29-0)
		3.105	P 37 (34-2)
680	18512.858	2.868	R 40 (34-2)
		2.855	P143 (32-0)
681	18512.695	2.751	R 74 (35-2)
		2.695	R 55 (28-0)
	18512.518	2.516	R 95 (36-2)
	18512.474	2.471	R 54 (31-1)
	18512.369	2.380	P 51 (31-1)
682	18512.197	2.197	P 52 (28-0)
	18512.050	2.042	R158 (33-0)
683	18511.887	1.889	P 38 (34-2)
684	18511.792	1.791	R146 (32-0)
685	18511.643	1.645	R 41 (34-2)
	18511.435	1.439	R111 (37-2)
686	18511.254	1.254	R114 (30-0)
687	18511.175	1.182	P 72 (35-2)
		1.174	R 56 (28-0)
688	18511.115	1.115	P111 (30-0)
689	18511.048	1.048	R 91 (29-0)
	18510.896	0.898	R 55 (31-1)
	18510.821	0.835	P 93 (36-2)
		0.806	P 52 (31-1)
690	18510.666	0.684	P166 (34-0)
		0.668	P 53 (28-0)
		0.642	P 39 (34-2)
691	18510.568	0.572	P 88 (29-0)
		0.540	P129 (31-0)
692	18510.402	0.413	R 75 (35-2)
		0.392	R 42 (34-2)
693	18510.150	0.160	P175 (35-0)
		0.149	R132 (31-0)
CALC	*********	9.887	P109 (37-2)
694	18509.624	9.624	R 57 (28-0)
	18509.432	9.429	R 96 (36-2)
	18509.365	9.365	P 40 (34-2)
	18509.294	9.295	R 56 (31-1)
	18509.204	9.204	P 53 (31-1)
695	18509.111	9.110	P 54 (28-0)
		9.107	R 43 (34-2)
696	18508.829	8.873	P156 (33-0)
		8.827	P 73 (35-2)
697	18508.448	8.448	R 92 (29-0)
698	18508.328	8.331	P144 (32-0)
699	18508.047	8.056	P 41 (34-2)
		8.047	R 58 (28-0)
		8.044	R 76 (35-2)
700	18507.971	7.971	P 89 (29-0)
701	18507.901	7.901	R115 (30-0)
		7.886	R169 (34-0)
702	18507.767	7.791	R 44 (34-2)
		7.767	P112 (30-0)
		7.735	P 94 (36-2)
		7.727	R112 (37-2)
	18507.661	7.663	R 57 (31-1)
703	18507.525	7.571	P 54 (31-1)
		7.525	P 55 (28-0)
704	18507.248	7.245	R147 (32-0)
	18507.176		
	18506.982	6.979	R159 (33-0)
705	18506.712	6.716	P 42 (34-2)
706	18506.558	6.558	P130 (31-0)
707	18506.441	6.443	R 45 (34-2)
		6.440	R 59 (28-0)
		6.439	P 74 (35-2)
	18506.312	6.308	R 97 (36-2)
708	18506.152	6.169	P110 (37-2)
		6.154	R133 (31-0)
	18505.999	6.000	R 58 (31-1)
709	18505.910	5.911	P 56 (28-0)
		5.909	P 55 (31-1)
710	18505.818	5.819	R 93 (29-0)
	18505.644	5.642	R 77 (35-2)
711	18505.341	5.345	P 43 (34-2)
		5.340	P 90 (29-0)
	18505.149	5.145	P167 (34-0)
712	18505.066	5.065	R 46 (34-2)
713	18504.806	4.806	R 60 (28-0)
	18504.604	4.601	P 95 (36-2)
714	18504.517	4.517	R116 (30-0)
715	18504.389	4.390	P113 (30-0)
716	18504.270	4.308	R 59 (31-1)
		4.269	P 57 (28-0)
		4.217	P 56 (31-1)
		4.158	P176 (35-0)
	18504.018	4.019	P 75 (35-2)
	18503.946	3.980	R113 (37-2)
		3.943	P 44 (34-2)
717	18503.775	3.805	P157 (33-0)
		3.772	P185 (32-0)
	18503.655	3.656	R 47 (34-2)
718	18503.148	3.207	R 78 (35-2)
		3.160	R 94 (29-0)
		3.153	R 98 (36-2)
		3.144	R 61 (28-0)
719	18502.679	2.680	P 91 (29-0)
		2.665	R148 (32-0)
720	18502.598	2.599	P 58 (28-0)
		2.587	R 60 (31-1)
721	18502.543	2.544	P131 (31-0)
		2.510	P 45 (34-2)
		2.496	P 57 (31-1)
	18502.417	2.417	P111 (37-2)
	18502.312	2.308	R170 (34-0)
	18502.215	2.215	R 48 (34-2)
722	18502.125	2.126	R134 (31-0)
	18501.878	1.881	R160 (33-0)
	18501.631		
	18501.567	1.567	P 76 (35-2)
723	18501.453	1.453	R 62 (28-0)
		1.434	P 96 (36-2)
724	18501.101	1.102	R117 (30-0)
		1.046	P 46 (34-2)
725	18500.981	0.981	P114 (30-0)
726	18500.901	0.901	P 59 (28-0)
		0.835	R 61 (31-1)
727	18500.743	0.745	P 58 (31-1)
		0.743	R 49 (34-2)
		0.740	R 79 (35-2)
728	18500.471	0.471	R 95 (29-0)
	18500.281		
	18500.200	0.198	R114 (37-2)
729	18499.989	9.991	P 92 (29-0)
		9.964	R 99 (36-2)
730	18499.733	9.733	R 63 (28-0)
731	18499.557	9.570	P168 (34-0)
		9.551	P 47 (34-2)



LINE	OBS CM-1	CALC	ASSIGNMENT
728	18500.471	0.471	R 95 (29-0)
	18500.281		
	18500.200	0.198	R114 (37-2)
729	18499.989	9.991	P 92 (29-0)
		9.964	R 99 (36-2)
730	18499.733	9.733	R 63 (28-0)
731	18499.557	9.570	P168 (34-0)
		9.551	P 47 (34-2)
	18499.314		
732	18499.175	9.240	R 50 (34-2)
		9.180	P146 (32-0)
		9.174	P 60 (28-0)
	18499.071	9.082	P 77 (35-2)
		9.054	R 62 (31-1)
	18498.961	8.964	P 59 (31-1)
	18498.708	8.702	P158 (33-0)
	18498.630	8.629	P112 (37-2)
733	18498.497	8.498	P132 (31-0)
734	18498.240	8.240	R 80 (35-2)
		8.233	P 97 (36-2)
735	18498.059	8.118	P177 (35-0)
		8.066	R135 (31-0)
		8.051	R149 (32-0)
		8.024	P 48 (34-2)
736	18497.986	7.986	R 64 (28-0)
737	18497.751	7.753	R 96 (29-0)
		7.706	R 51 (34-2)
738	18497.656	7.657	R118 (30-0)
739	18497.541	7.542	P115 (30-0)
740	18497.419	7.419	P 61 (28-0)
741	18497.270	7.272	P 93 (29-0)
		7.243	R 63 (31-1)
	18497.154	7.153	P 60 (31-1)
	18496.750	6.747	R161 (33-0)
		6.741	R100 (36-2)
	18496.678	6.693	R171 (34-0)
	18496.565	6.564	P 78 (35-2)
	18496.461	6.467	P 49 (34-2)
742	18496.209	6.210	R 65 (28-0)
		6.140	R 52 (34-2)
	18495.708	5.708	R 81 (35-2)
743	18495.636	5.636	P 62 (28-0)
	18495.401	5.402	R 64 (31-1)
744	18495.311	5.313	P 61 (31-1)
745	18495.003	5.005	R 97 (29-0)
		4.998	P 98 (36-2)
	18494.876	4.878	P 50 (34-2)
	18494.806	4.805	P113 (37-2)
746	18494.526	4.555	P147 (32-0)
		4.543	R 53 (34-2)
		4.523	P 94 (29-0)
747	18494.408	4.420	P133 (31-0)
		4.405	R 66 (28-0)
748	18494.179	4.180	R119 (30-0)
749	18494.071	4.072	P116 (30-0)
750	18493.971	4.015	P 79 (35-2)
		3.974	R136 (31-0)
		3.957	P169 (34-0)
751	18493.824	3.825	P 63 (28-0)
	18493.663		
	18493.538	3.563	P159 (33-0)
		3.531	R 65 (31-1)
		3.486	R101 (36-2)
752	18493.409	3.443	P 62 (31-1)
		3.403	R150 (32-0)
753	18493.258	3.258	P 51 (34-2)
	18493.144	3.143	R 82 (35-2)
754	18492.915	2.915	R 54 (34-2)
755	18492.572	2.572	R 67 (28-0)
	18492.403		
756	18492.226	2.227	R 98 (29-0)
757	18491.985	2.039	P178 (35-0)
		1.985	P 64 (28-0)
758	18491.744	1.745	P 95 (29-0)
		1.729	P 99 (36-2)
	18491.606	1.630	R 66 (31-1)
		1.607	P 52 (34-2)
	18491.549	1.578	R162 (33-0)
		1.543	P 63 (31-1)
	18491.433	1.433	P 80 (35-2)
759	18491.255	1.256	R 55 (34-2)
	18491.035	1.041	R172 (34-0)
	18490.946	0.947	P114 (37-2)
	18490.865		
760	18490.709	0.711	R 68 (28-0)
		0.673	R120 (30-0)
761	18490.569	0.571	P117 (30-0)
		0.546	R 83 (35-2)
762	18490.309	0.310	P134 (31-0)
763	18490.117	0.194	R102 (36-2)
		0.117	P 65 (28-0)
	18489.906	9.925	P 53 (34-2)
		9.896	P148 (32-0)
764	18489.850	9.849	R137 (31-0)
765	18489.700	9.699	R 67 (31-1)
	18489.567	9.613	P 64 (31-1)
		9.565	R 56 (34-2)
766	18489.419	9.420	R 99 (29-0)
767	18488.937	8.938	P 96 (29-0)
768	18488.822	8.822	R 69 (28-0)
		8.818	P 81 (35-2)
769	18488.728	8.721	R151 (32-0)
	18488.644		
	18488.400	8.427	P100 (36-2)
		8.389	P160 (33-0)
	18488.311	8.308	P170 (34-0)
770	18488.220	8.220	P 66 (28-0)
		8.211	P 54 (34-2)
	18488.048		
	18487.915	7.916	R 84 (35-2)
	18487.845	7.843	R 57 (34-2)
	18487.746	7.739	R 68 (31-1)
	18487.655	7.654	P 65 (31-1)
771	18487.134	7.134	R121 (30-0)
772	18487.040	7.040	P118 (30-0)
773	18486.903	6.904	R 70 (28-0)
		6.869	R103 (36-2)
774	18486.582	6.583	R100 (29-0)
	18486.464	6.466	P 55 (34-2)
	18486.377	6.372	R163 (33-0)
775	18486.296	6.296	P 67 (28-0)
776	18486.169	6.171	P 82 (35-2)
		6.167	P135 (31-0)
777	18486.099	6.101	P 97 (29-0)
		6.090	R 58 (34-2)
	18485.915	5.920	P179 (35-0)
778	18485.684	5.748	R 69 (31-1)
		5.692	R138 (31-0)
		5.664	P 66 (31-1)
	18485.353	5.352	R175 (34-0)
779	18485.202	5.253	R 85 (35-2)
		5.203	P149 (32-0)
	18485.093	5.090	P101 (36-2)
780	18484.958	4.957	R 71 (28-0)
781	18484.691	4.690	P 56 (34-2)
CALC	**********	4.467	R 1 (30-1)
CALC	**********	4.455	R 2 (30-1)
CALC	**********	4.450	R 0 (30-1)
CALC	**********	4.415	R 3 (30-1)
782	18484.342	4.345	R 4 (30-1)
		4.342	P 68 (28-0)
		4.330	P 1 (30-1)
		4.305	R 59 (34-2)
		4.247	R 5 (30-1)
		4.227	P 2 (30-1)
	18484.112	4.121	R 6 (30-1)
		4.095	P 3 (30-1)
	18484.005	4.006	R152 (32-0)
		3.965	R 7 (30-1)
		3.934	P 4 (30-1)
783	18483.717	3.781	R 8 (30-1)
		3.745	P 5 (30-1)
		3.728	R 70 (31-1)
		3.716	R101 (29-0)
784	18483.646	3.645	P 67 (31-1)
785	18483.564	3.569	R 9 (30-1)
		3.565	R122 (30-0)
786	18483.479	3.527	P 6 (30-1)
		3.510	R104 (36-2)
		3.491	P 83 (35-2)
		3.477	P119 (30-0)
	18483.326	3.327	R 10 (30-1)
787	18483.234	3.280	P 7 (30-1)
		3.234	P 98 (29-0)
		3.180	P161 (33-0)
788	18482.983	3.057	R 11 (30-1)
		3.005	P 8 (30-1)
		2.982	R 72 (28-0)
	18482.880	2.883	P 57 (34-2)
	18482.758	2.758	R 12 (30-1)
	18482.702	2.701	P 9 (30-1)
	18482.625	2.622	P171 (34-0)
	18482.558	2.558	R 86 (35-2)
	18482.488	2.489	R 60 (34-2)
789	18482.361	2.430	R 13 (30-1)
		2.368	P 10 (30-1)
		2.361	P 69 (28-0)
	18482.174		
	18482.074	2.073	R 14 (30-1)
790	18481.996	2.006	P 11 (30-1)
		1.993	P136 (31-0)
791	18481.683	1.720	P102 (36-2)
		1.688	R 15 (30-1)
		1.677	R 71 (31-1)
	18481.603	1.616	P 12 (30-1)
		1.596	P 68 (31-1)
792	18481.501	1.503	R139 (31-0)
	18481.275	1.274	R 16 (30-1)
	18481.198	1.197	P 13 (30-1)
	18481.140	1.132	R164 (33-0)
793	18480.978	1.044	P 58 (34-2)
		0.978	R 73 (28-0)
794	18480.819	0.831	R 17 (30-1)
		0.820	R102 (29-0)
		0.779	P 84 (35-2)
		0.749	P 14 (30-1)
	18480.641	0.641	R 61 (34-2)
795	18480.476	0.476	P150 (32-0)
796	18480.346	0.360	R 18 (30-1)
		0.351	P 70 (28-0)
		0.338	P 99 (29-0)
		0.272	P 15 (30-1)
	18480.111	0.117	R105 (36-2)
797	18479.963	9.964	R123 (30-0)
798	18479.881	9.884	P120 (30-0)
		9.859	R 19 (30-1)
		9.829	R 87 (35-2)
	18479.765	9.767	P 16 (30-1)
799	18479.595	9.624	R174 (34-0)
		9.597	R 72 (31-1)
	18479.518	9.517	P 69 (31-1)



LINE	OBS CM-1	CALC	ASSIGNMENT
795	18480.476	0.476	P150 (32-0)
796	18480.346	0.360	R 18 (30-1)
		0.351	P 70 (28-0)
		0.338	P 99 (29-0)
		0.272	P 15 (30-1)
	18480.111	0.117	R105 (36-2)
797	18479.963	9.964	R123 (30-0)
798	18479.881	9.884	P120 (30-0)
		9.859	R 19 (30-1)
		9.829	R 87 (35-2)
	18479.765	9.767	P 16 (30-1)
799	18479.595	9.624	R174 (34-0)
		9.597	R 72 (31-1)
	18479.518	9.517	P 69 (31-1)
	18479.333	9.330	R 20 (30-1)
	18479.249	9.256	R153 (32-0)
		9.233	P 17 (30-1)
800	18479.172	9.174	P 59 (34-2)
801	18478.986	8.946	R 74 (28-0)
802	18478.769	8.772	R 21 (30-1)
		8.762	R 62 (34-2)
	18478.672	8.670	P 18 (30-1)
803	18478.313	8.316	P103 (36-2)
		8.313	P 71 (28-0)
	18478.186	8.186	R 22 (30-1)
	18478.042	8.079	P 19 (30-1)
		8.034	P 85 (35-2)
804	18477.894	7.936	P162 (33-0)
		7.894	R103 (29-0)
805	18477.722	7.786	P137 (31-0)
		7.748	R 1 (27-0)
		7.740	R 2 (27-0)
		7.728	R 0 (27-0)
		7.706	R 3 (27-0)
806	18477.641	7.643	R 4 (27-0)
		7.606	P 1 (27-0)
807	18477.555	7.570	R 23 (30-1)
		7.554	R 5 (27-0)
		7.504	P 2 (27-0)
808	18477.416	7.486	R 73 (31-1)
		7.458	P 20 (30-1)
		7.437	R 6 (27-0)
		7.412	P100 (29-0)
		7.408	P 70 (31-1)
		7.375	P 3 (27-0)
809	18477.286	7.293	R 7 (27-0)
		7.280	R140 (31-0)
		7.273	P 60 (34-2)
	18477.218	7.218	P 4 (27-0)
810	18477.120	7.121	R 8 (27-0)
811	18477.033	7.064	R 88 (35-2)
		7.034	P 5 (27-0)
812	18476.890	6.926	R 24 (30-1)
		6.922	R 9 (27-0)
		6.898	P172 (34-0)
		6.886	R 75 (28-0)
		6.852	R 63 (34-2)
813	18476.826	6.822	P 6 (27-0)
		6.809	P 21 (30-1)
814	18476.694	6.696	R 10 (27-0)
815	18476.583	6.584	P 7 (27-0)
816	18476.440	6.442	R 11 (27-0)
817	18476.323	6.332	R124 (30-0)
		6.317	P 8 (27-0)
818	18476.249	6.260	P121 (30-0)
		6.253	R 25 (30-1)
		6.246	P 72 (28-0)
819	18476.157	6.161	R 12 (27-0)
		6.131	P 22 (30-1)
820	18476.023	6.024	P 9 (27-0)
821	18475.851	5.855	R165 (33-0)
		5.853	R 13 (27-0)
822	18475.705	5.716	P151 (32-0)
		5.703	P 10 (27-0)
823	18475.517	5.551	R 26 (30-1)
		5.517	R 14 (27-0)
824	18475.429	5.425	P 23 (30-1)
825	18475.350	5.355	P 11 (27-0)
		5.346	R 74 (31-1)
		5.340	P 61 (34-2)
826	18475.270	5.269	P 71 (31-1)
		5.256	P 86 (35-2)
827	18475.152	5.154	R 15 (27-0)
828	18474.941	4.979	P 12 (27-0)
		4.938	R104 (29-0)
		4.910	R 64 (34-2)
		4.878	P104 (36-2)
829	18474.792	4.820	R 27 (30-1)
		4.797	R 76 (28-0)
		4.763	R 16 (27-0)
	18474.690	4.689	P 24 (30-1)
830	18474.576	4.576	P 13 (27-0)
831	18474.459	4.472	R154 (32-0)
		4.457	P101 (29-0)
832	18474.344	4.345	R 17 (27-0)
		4.274	R 89 (35-2)
833	18474.149	4.150	P 73 (28-0)
		4.146	P 14 (27-0)
	18474.061	4.061	R 28 (30-1)
834	18473.900	3.925	P 25 (30-1)
		3.900	R 18 (27-0)
		3.859	R175 (34-0)
835	18473.687	3.688	P 15 (27-0)
836	18473.546	3.546	P138 (31-0)
837	18473.426	3.427	R 19 (27-0)
		3.376	P 62 (34-2)
	18473.270	3.272	R 29 (30-1)
838	18473.201	3.203	P 16 (27-0)
		3.175	R 75 (31-1)
	18473.129	3.132	P 26 (30-1)
		3.101	P 72 (31-1)
839	18473.027	3.025	R141 (31-0)
840	18472.927	2.937	R 65 (34-2)
		2.927	R 20 (27-0)
841	18472.680	2.691	P 17 (27-0)
		2.679	R 77 (28-0)
		2.669	R125 (30-0)
		2.656	P163 (33-0)
842	18472.607	2.605	P122 (30-0)
843	18472.398	2.455	R 30 (30-1)
		2.446	P 87 (35-2)
		2.399	R 21 (27-0)
844	18472.318	2.310	P 27 (30-1)
845	18472.151	2.151	P 18 (27-0)
846	18472.028	2.027	R 74 (28-0)
847	18471.952	1.952	R105 (29-0)
848	18471.842	1.844	R 22 (27-0)
849	18471.584	1.609	R 31 (30-1)
		1.584	P 19 (27-0)
850	18471.470	1.472	P102 (29-0)
		1.460	P 28 (30-1)
		1.448	R 90 (35-2)
851	18471.387	1.406	P105 (36-2)
		1.381	P 63 (34-2)
852	18471.260	1.262	R 23 (27-0)
	18471.131	1.138	P173 (34-0)
853	18470.989	0.989	P 20 (27-0)
		0.975	R 76 (31-1)
854	18470.920	0.932	R 66 (34-2)
		0.921	P152 (32-0)
		0.902	P 73 (31-1)
855	18470.734	0.734	R 32 (30-1)
856	18470.650	0.652	P 24 (27-0)
857	18470.533	0.580	P 29 (30-1)
		0.542	R166 (33-0)
		0.533	R 78 (28-0)
858	18470.365	0.367	P 21 (27-0)
859	18470.014	0.015	R 25 (27-0)
860	18469.875	9.875	P 75 (26-0)
		9.830	R 33 (30-1)
861	18469.717	9.718	P 22 (27-0)
		9.672	P 30 (30-1)
		9.653	R155 (32-0)
		9.603	P 88 (35-2)
862	18469.349	9.354	P 64 (34-2)
		9.350	R 26 (27-0)
863	18469.273	9.274	P139 (31-0)
864	18469.039	9.041	P 23 (27-0)
865	18468.927	8.975	R126 (30-0)
		8.936	R106 (29-0)
		8.919	P123 (30-0)
		8.898	R 34 (30-1)
		8.895	R 67 (34-2)
866	18468.738	8.744	R 77 (31-1)
		8.738	R142 (31-0)
		8.735	P 31 (30-1)
867	18468.658	8.673	P 74 (31-1)
		8.658	R 27 (27-0)
		8.588	R 91 (35-2)
868	18468.458	8.457	P103 (29-0)
869	18468.349	8.358	R 79 (28-0)
		8.337	P 24 (27-0)
	18468.153		
	18468.099	8.057	R176 (34-0)
870	18467.937	7.938	R 28 (27-0)
		7.936	R 35 (30-1)
		7.900	P106 (36-2)
	18467.768	7.769	P 32 (30-1)
871	18467.695	7.694	P 76 (28-0)
872	18467.604	7.605	P 25 (27-0)
873	18467.298	7.340	P164 (33-0)
		7.296	P 65 (34-2)
874	18467.190	7.191	R 29 (27-0)
875	18466.947	6.946	R 36 (30-1)
876	18466.844	6.846	P 26 (27-0)
		6.827	R 68 (34-2)
		6.774	P 33 (30-1)
		6.728	P 89 (35-2)
877	18466.416	6.483	R 78 (31-1)
		6.417	R 30 (27-0)
		6.415	P 75 (31-1)
878	18466.156	6.154	R 80 (28-0)
		6.093	P153 (32-0)
879	18466.059	6.060	P 27 (27-0)
880	18465.892	5.927	R 37 (30-1)
		5.891	R107 (29-0)
881	18465.750	5.751	P 34 (30-1)
	18465.704	5.696	R 92 (35-2)
882	18465.614	5.615	R 31 (27-0)
883	18465.485	5.485	P 77 (28-0)
884	18465.413	5.413	P104 (29-0)
	18465.340	5.340	P174 (34-0)
885	18465.245	5.249	R127 (30-0)
		5.246	P 28 (27-0)
		5.206	P 66 (34-2)
		5.202	P124 (30-0)
		5.194	R167 (33-0)
886	18464.970	4.970	P140 (31-0)
	18464.866	4.878	R 38 (30-1)
887	18464.785	4.801	R156 (32-0)
		4.785	R 32 (27-0)
888	18464.717	4.727	R 69 (34-2)
		4.698	P 35 (30-1)
889	18464.405	4.418	R143 (31-0)
		4.404	P 29 (27-0)
		4.360	P107 (36-2)
890	18464.185	4.192	R 79 (31-1)
	18464.116	4.126	P 76 (31-1)
891	18463.925	3.928	R 33 (27-0)
		3.922	R 81 (28-0)
892	18463.807	3.819	P 90 (35-2)
		3.801	R 39 (30-1)
	18463.617	3.617	P 36 (30-1)
893	18463.535	3.536	P 30 (27-0)
	18463.407	3.404	P 24 (33-2)
	18463.332		
894	18463.247	3.247	P 78 (28-0)
895	18463.044	3.084	P 67 (34-2)
		3.044	R 34 (27-0)
896	18462.814	2.815	R108 (29-0)
		2.771	R 93 (35-2)
897	18462.638	2.695	R 40 (30-1)
		2.639	P 31 (27-0)
		2.604	P 25 (33-2)
		2.596	R 70 (34-2)
898	18462.516	2.507	P 37 (30-1)
899	18462.338	2.339	P105 (29-0)
900	18462.131	2.216	R177 (34-0)
		2.132	R 35 (27-0)
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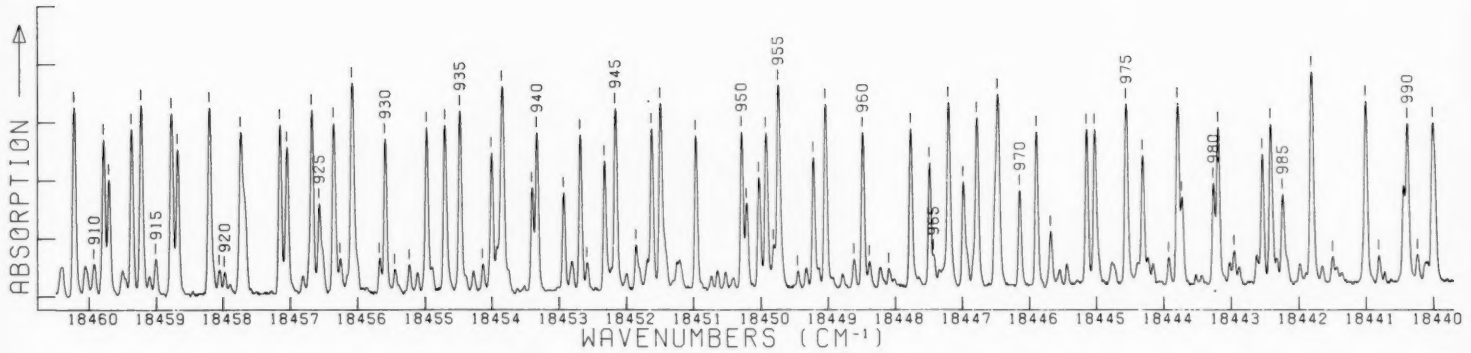
	18461.867	1.870	R 80 (31-1)
	18461.794	1.807	P 77 (31-1)
		1.775	P 26 (33-2)
901	18461.715	1.716	P 32 (27-0)
902	18461.663	1.661	R 82 (28-0)
903	18461.563	1.560	R 41 (30-1)
904	18461.455	1.493	R128 (30-0)
		1.453	P125 (30-0)
	18461.367	1.368	P 38 (30-1)
905	18461.193	1.231	R154 (32-0)
		1.193	R 36 (27-0)
906	18460.980	0.981	P 79 (28-0)
		0.932	P 68 (34-2)
		0.915	P 27 (33-2)
		0.878	P 91 (35-2)
907	18460.764	0.786	P108 (36-2)
		0.765	P 33 (27-0)
908	18460.632	0.633	R141 (31-0)
	18460.409	0.433	P 71 (34-2)
		0.396	R 42 (30-1)
909	18460.224	0.226	R 37 (27-0)
		0.200	P 39 (30-1)
	18460.054	0.064	R144 (31-0)
		0.025	P 28 (33-2)
910	18459.928	9.914	R157 (32-0)
911	18459.787	9.812	R 94 (35-2)
		9.809	R168 (33-0)
		9.786	P 34 (27-0)
912	18459.709	9.710	R109 (29-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
	18460.409	0.433	R 71 (34-2)
		0.396	R 42 (30-1)
909	18460.224	0.226	R 37 (27-0)
		0.200	P 39 (30-1)
	18460.054	0.064	R144 (31-0)
		0.025	P 28 (33-2)
910	18459.928	9.914	R157 (32-0)
911	18459.787	9.812	R 94 (35-2)
		9.809	R168 (33-0)
		9.786	P 34 (27-0)
912	18459.709	9.710	R109 (29-0)
	18459.509	9.519	R 81 (31-1)
		9.504	P175 (34-0)
		9.458	P 78 (31-1)
913	18459.372	9.371	R 83 (28-0)
914	18459.231	9.235	P106 (29-0)
		9.232	R 38 (27-0)
		9.203	R 43 (30-1)
	18459.109	9.104	P 29 (33-2)
915	18459.010	9.003	P 40 (30-1)
916	18458.779	8.780	P 35 (27-0)
		8.747	P 69 (34-2)
917	18458.687	8.686	P 80 (28-0)
918	18458.210	8.239	R 72 (34-2)
		8.210	R 39 (27-0)
		8.153	P 30 (33-2)
919	18458.061		
920	18457.984	7.981	R 44 (30-1)
	18457.907	7.904	P 92 (35-2)
921	18457.747	7.777	P 41 (30-1)
		7.747	P 36 (27-0)
		7.705	R129 (30-0)
		7.674	P126 (30-0)
922	18457.161	7.177	P109 (36-2)
		7.172	P 31 (33-2)
		7.160	R 40 (27-0)
		7.137	R 82 (31-1)
923	18457.056	7.079	P 79 (31-1)
		7.053	R 84 (28-0)
	18456.821	6.821	R 95 (35-2)
924	18456.686	6.731	R 45 (30-1)
		6.686	P 37 (27-0)
925	18456.574	6.602	P166 (33-0)
		6.575	R110 (29-0)
		6.531	P 70 (34-2)
		6.523	P 42 (30-1)
926	18456.361	6.362	P 81 (28-0)
		6.338	R178 (34-0)
		6.334	P155 (32-0)
927	18456.265	6.264	P142 (31-0)
	18456.161	6.160	P 32 (33-2)
928	18456.087	6.101	P107 (29-0)
		6.083	R 41 (27-0)
		6.012	R 73 (34-2)
929	18455.678	5.678	R145 (31-0)
930	18455.597	5.597	P 38 (27-0)
931	18455.452	5.451	R 46 (30-1)
932	18455.239	5.239	P 43 (30-1)
	18455.119	5.119	P 33 (33-2)
933	18454.980	4.992	R158 (32-0)
		4.979	R 42 (27-0)
	18454.898	4.898	P 93 (35-2)
934	18454.707	4.725	R 83 (31-1)
		4.706	R 85 (28-0)
		4.670	P 80 (31-1)
935	18454.482	4.481	P 39 (27-0)
	18454.395	4.388	R169 (33-0)
	18454.283	4.284	P 71 (34-2)
936	18454.142	4.142	R 47 (30-1)
937	18454.010	4.046	P 34 (33-2)
		4.010	P 82 (28-0)
938	18453.851	3.926	P 44 (30-1)
		3.885	R130 (30-0)
		3.864	P127 (30-0)
		3.847	R 43 (27-0)
		3.796	R 96 (35-2)
	18453.759	3.754	R 74 (34-2)
	18453.627	3.631	P176 (34-0)
	18453.531	3.535	P110 (36-2)
939	18453.410	3.409	R111 (29-0)
940	18453.339	3.338	P 40 (27-0)
941	18452.938	2.944	P 35 (33-2)
		2.937	P108 (29-0)
	18452.814	2.804	R 48 (30-1)
942	18452.688	2.687	R 44 (27-0)
943	18452.588	2.585	P 45 (30-1)
944	18452.331	2.330	R 86 (28-0)
		2.283	R 84 (31-1)
945	18452.168	2.231	P 81 (31-1)
		2.167	P 41 (27-0)
	18452.008	2.005	P 72 (34-2)
946	18451.862	1.862	P143 (31-0)
		1.858	P 94 (35-2)
		1.811	P 36 (33-2)
	18451.699		
947	18451.631	1.629	P 83 (28-0)
948	18451.500	1.500	R 45 (27-0)
		1.465	R 75 (34-2)
		1.437	R 49 (30-1)
		1.404	P156 (32-0)
	18451.212	1.260	R146 (31-0)
		1.214	P 46 (30-1)
		1.179	P167 (33-0)
949	18450.969	0.968	P 42 (27-0)
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	18450.649	0.648	P 37 (33-2)
	18450.529	0.529	R 40 (33-2)
	18450.417	0.422	R179 (34-0)
950	18450.286	0.285	R 46 (27-0)
951	18450.215	0.214	R112 (29-0)
952	18450.032	0.041	R 50 (30-1)
		0.036	R159 (32-0)
		0.034	R131 (30-0)
		0.022	P128 (30-0)
953	18449.927	9.926	R 87 (28-0)
954	18449.816	9.815	P 47 (30-1)
		9.810	R 85 (31-1)
955	18449.744	9.762	P 82 (31-1)
		9.744	P109 (29-0)
		9.742	P 43 (27-0)
		9.694	P 73 (34-2)
956	18449.453	9.454	P 38 (33-2)
	18449.331	9.332	R 41 (33-2)
957	18449.221	9.220	P 84 (28-0)
	18449.148	9.143	R 76 (34-2)
958	18449.044	9.043	R 47 (27-0)
	18448.936	8.931	R170 (33-0)
	18448.787	8.785	P 95 (35-2)
959	18448.618	8.616	R 51 (30-1)
960	18448.490	8.489	P 44 (27-0)
961	18448.389	8.387	P 48 (30-1)
	18448.230	8.230	P 39 (33-2)
962	18448.103	8.103	R 42 (33-2)
	18448.025		
963	18447.775	7.773	R 48 (27-0)
	18447.652	7.648	R 98 (35-2)
964	18447.493	7.492	R 88 (28-0)
965	18447.433	7.428	P144 (31-0)
	18447.348	7.352	P 74 (34-2)
		7.308	R 86 (31-1)
		7.262	P 83 (31-1)
966	18447.209	7.208	P 45 (27-0)
		7.162	R 52 (30-1)
967	18446.988	6.988	R113 (29-0)
		6.975	P 40 (33-2)
		6.929	P 49 (30-1)
968	18446.785	6.845	R 43 (33-2)
		6.808	R147 (31-0)
		6.790	R 77 (34-2)
969	18446.478	6.782	P 85 (28-0)
		6.520	P110 (29-0)
		6.475	R 49 (27-0)
		6.439	P157 (32-0)
970	18446.149	6.152	R132 (30-0)
		6.149	P129 (30-0)
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972	18445.686	5.721	P168 (33-0)
		5.690	P 41 (33-2)
		5.680	P 96 (35-2)
		5.678	R 53 (30-1)
	18445.555	5.556	R 44 (33-2)
	18445.443	5.443	P 50 (30-1)
973	18445.151	5.150	R 50 (27-0)
974	18445.031	5.045	R160 (32-0)
		5.030	R 89 (28-0)
		4.978	P 75 (34-2)
	18444.775	4.774	R 87 (31-1)
		4.732	P 84 (31-1)
975	18444.564	4.563	P 47 (27-0)
		4.525	R 99 (35-2)
	18444.385	4.405	R 78 (34-2)
		4.375	P 42 (33-2)
976	18444.317	4.315	P 86 (28-0)
	18444.238	4.236	R 45 (33-2)
	18444.167	4.166	R 54 (30-1)
977	18443.928	3.927	P 51 (30-1)
978	18443.798	3.797	R 51 (27-0)
979	18443.735	3.732	R114 (29-0)
	18443.642	3.638	R171 (33-0)
980	18443.268	3.267	P111 (29-0)
981	18443.201	3.199	P 48 (27-0)
	18443.028	3.029	P 43 (33-2)
982	18442.961	2.960	P145 (31-0)
	18442.885	2.886	R 46 (33-2)
	18442.623	2.625	R 55 (30-1)
983	18442.541	2.572	P 76 (34-2)
		2.541	P 97 (35-2)
		2.539	R 90 (28-0)
984	18442.417	2.416	R 52 (27-0)
		2.383	P 52 (30-1)
	18442.323	2.323	R148 (31-0)
985	18442.241	2.245	P130 (30-0)
		2.238	R133 (30-0)
		2.211	R 88 (31-1)
		2.172	P 85 (31-1)
	18441.988	1.988	R 79 (34-2)
986	18441.813	1.820	P 87 (28-0)
		1.808	P 49 (27-0)
	18441.656	1.653	P 44 (33-2)
987	18441.499	1.505	R 47 (33-2)
	18441.441	1.440	P158 (32-0)
	18441.370	1.368	R100 (35-2)
988	18441.010	1.054	R 56 (30-1)
		1.008	R 53 (27-0)
989	18440.812	0.809	P 53 (30-1)
990	18440.391	0.447	R115 (29-0)
		0.389	P 50 (27-0)
991	18440.240	0.246	P 45 (33-2)
		0.227	P169 (33-0)
	18440.103	0.135	P 77 (34-2)
		0.094	R 48 (33-2)
992	18440.017	0.020	R161 (32-0)
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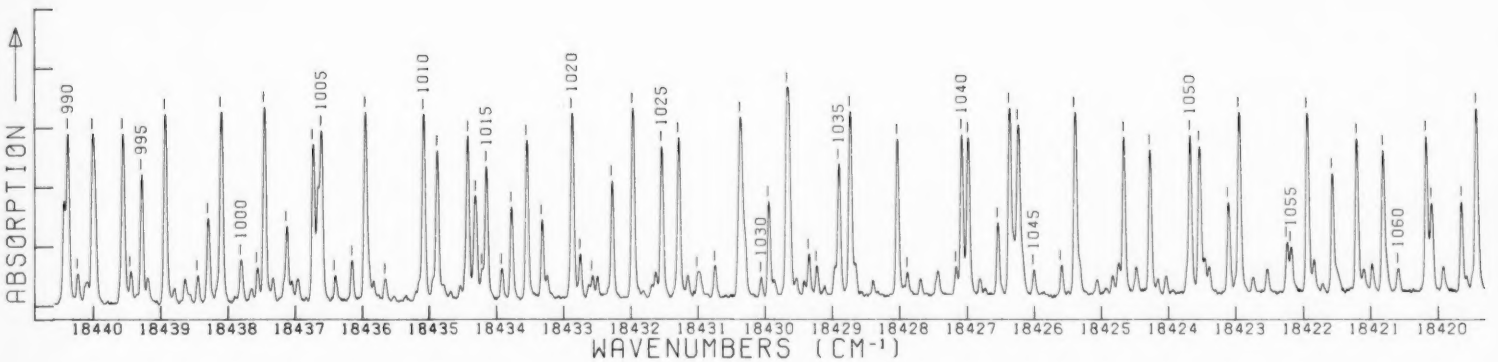

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		0.227	P169 (33-0)
	18440.103	0.135	P 77 (34-2)
		0.094	R 48 (33-2)
992	18440.017	0.020	R161 (32-0)
		0.019	R 91 (28-0)
		9.983	P112 (29-0)
993	18439.574	9.617	R 89 (31-1)
		9.582	P 86 (31-1)
		9.572	R 54 (27-0)
		9.539	R 80 (34-2)
994	18439.455	9.454	R 57 (30-1)
	18439.373	9.370	P 98 (35-2)
995	18439.296	9.296	P 88 (28-0)
	18439.205	9.207	P 54 (30-1)
996	18438.944	8.942	P 51 (27-0)
	18438.809	8.809	P 46 (33-2)
	18438.647	8.652	R 49 (33-2)
997	18438.459	8.460	P146 (31-0)
998	18438.302	8.309	P131 (30-0)
		8.292	R134 (30-0)
999	18438.110	8.178	R101 (35-2)
		8.109	R 55 (27-0)
	18437.910	7.909	R172 (33-0)
1000	18437.814	7.825	R 58 (30-1)
		7.805	R149 (31-0)
	18437.666	7.665	P 78 (34-2)
1001	18437.575	7.575	P 55 (30-1)
1002	18437.469	7.471	R 92 (28-0)
		7.468	P 52 (27-0)
	18437.342	7.341	P 47 (33-2)
1003	18437.131	7.179	R 50 (33-2)
		7.131	R116 (29-0)
	18437.061	7.058	R 81 (34-2)
	18436.972	6.992	R 90 (31-1)
		6.962	P 87 (31-1)
1004	18436.743	6.743	P 89 (28-0)
1005	18436.621	6.670	P113 (29-0)
		6.618	R 56 (27-0)
1006	18436.414	6.406	P159 (32-0)
1007	18436.167	6.167	R 59 (30-1)
		6.165	P 99 (35-2)
1008	18435.967	5.966	P 53 (27-0)
		5.914	P 56 (30-1)
	18435.844	5.843	P 48 (33-2)
1009	18435.674	5.676	R 51 (33-2)
1010	18435.100	5.165	P 79 (34-2)
		5.099	R 57 (27-0)
	18434.958	4.960	R162 (32-0)
		4.955	R102 (35-2)
1011	18434.893	4.893	R 93 (28-0)
	18434.696	4.696	P170 (33-0)
	18434.548	4.546	R 82 (34-2)
1012	18434.438	4.480	R 60 (30-1)
		4.437	P 54 (27-0)
1013	18434.323	4.342	P132 (30-0)
		4.337	R 91 (31-1)
		4.315	R135 (30-0)
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		4.311	P 88 (31-1)
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1015	18434.161	4.161	P 90 (28-0)
		4.142	R 52 (33-2)
1016	18433.929	3.928	P147 (31-0)
1017	18433.785	3.784	R117 (29-0)
1018	18433.553	3.552	R 58 (27-0)
1019	18433.327	3.327	P114 (29-0)
	18433.254	3.254	R150 (31-0)
1020	18432.882	2.928	P100 (35-2)
		2.879	P 55 (27-0)
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		2.755	P 50 (33-2)
	18432.631	2.632	P 80 (34-2)
1022	18432.579	2.578	R 53 (33-2)
	18432.506	2.505	P 58 (30-1)
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		2.001	R 83 (34-2)
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		1.629	P 89 (31-1)
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1026	18431.297	1.339	P160 (32-0)
		1.295	P 56 (27-0)
	18431.165	1.165	P 51 (33-2)
1027	18431.014	1.018	R 62 (30-1)
		0.983	R 54 (33-2)
1028	18430.757	0.757	P 59 (30-1)
1029	18430.378	0.408	R118 (29-0)
		0.375	R 60 (27-0)
		0.344	P133 (30-0)
		0.307	R136 (30-0)
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	18429.871	9.865	R163 (32-0)
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		9.657	P101 (35-2)
		9.651	R 95 (28-0)
	18429.544	9.544	P 52 (33-2)
	18429.427	9.425	R 84 (34-2)
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		9.357	R 55 (33-2)
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	18429.131	9.130	P171 (33-0)
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		8.936	R 93 (31-1)
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	18428.670	8.670	R151 (31-0)
	18428.405	8.408	R104 (35-2)
1037	18428.043	8.042	P 58 (27-0)
1038	18427.892	7.893	P 53 (33-2)
	18427.700	7.701	R 56 (33-2)
	18427.446	7.471	P 82 (34-2)
		7.439	R 64 (30-1)
1039	18427.174	7.173	P 61 (30-1)
1040	18427.090	7.088	R 62 (27-0)
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		6.986	R 96 (28-0)
	18426.819	6.816	R 85 (34-2)
	18426.740	6.740	R174 (33-0)
1042	18426.550	6.550	P116 (29-0)
1043	18426.376	6.374	P 59 (27-0)
		6.353	P102 (35-2)
		6.315	P134 (30-0)
1044	18426.246	6.266	R137 (30-0)
		6.243	P 93 (28-0)
		6.236	P161 (32-0)
		6.211	P 54 (33-2)
		6.189	R 94 (31-1)
		6.176	P 91 (31-1)
1045	18426.012	6.014	R 57 (33-2)
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1047	18425.404	5.402	R 63 (27-0)
		5.337	P 62 (30-1)
	18425.079	5.085	R105 (35-2)
	18424.843	4.842	P 83 (34-2)
	18424.757	4.763	P149 (31-0)
		4.736	R164 (32-0)
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	18424.496	4.499	P 55 (33-2)
1049	18424.293	4.296	R 58 (33-2)
		4.293	R 97 (28-0)
	18424.178	4.176	R 86 (34-2)
	18424.052	4.052	R152 (31-0)
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		3.689	R 64 (27-0)
1051	18423.551	3.564	R120 (29-0)
		3.546	P 94 (28-0)
		3.527	P172 (33-0)
	18423.475	3.473	P 63 (30-1)
	18423.409	3.412	R 95 (31-1)
		3.404	P 92 (31-1)
1052	18423.117	3.116	P117 (29-0)
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		2.955	P 61 (27-0)
	18422.755	2.756	P 56 (33-2)
	18422.546	2.547	R 59 (33-2)
1054	18422.252	2.253	P135 (30-0)
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		2.182	P 84 (34-2)
1056	18421.950	1.948	R 65 (27-0)
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	18421.727	1.728	R106 (35-2)
1057	18421.572	1.578	P 64 (30-1)
		1.570	R 98 (28-0)
		1.503	R 87 (34-2)
1058	18421.207	1.204	P 62 (27-0)
	18421.104	1.101	R175 (33-0)
		1.100	P162 (32-0)
	18420.982	0.982	P 57 (33-2)
1059	18420.822	0.820	P 95 (28-0)
		0.768	R 60 (33-2)
1060	18420.600	0.604	R 96 (31-1)
		0.601	P 93 (31-1)
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		0.132	P150 (31-0)
1062	18420.099	0.097	R121 (29-0)
	18419.926	9.929	R 68 (30-1)
1063	18419.653	9.655	P 65 (30-1)
		9.653	P118 (29-0)
		9.646	P104 (35-2)
	18419.577	9.571	R165 (32-0)
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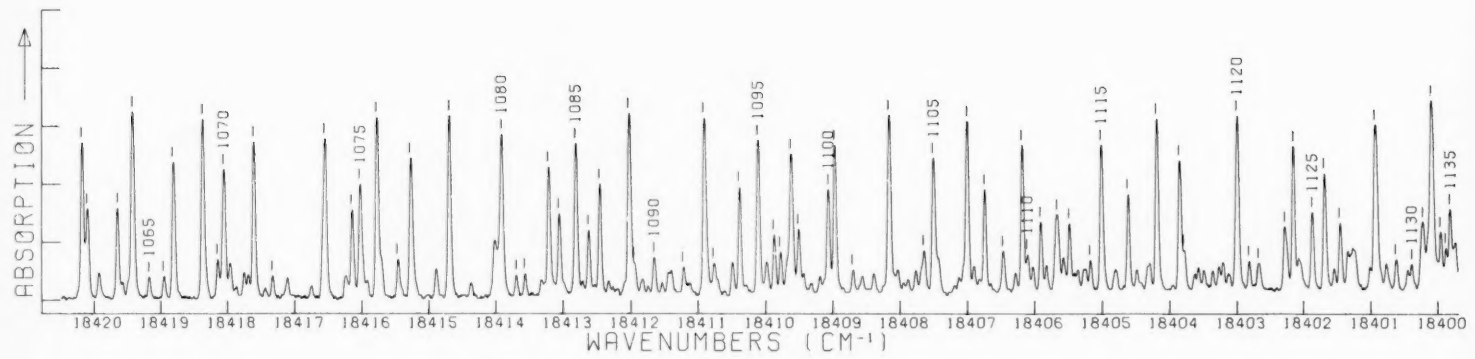

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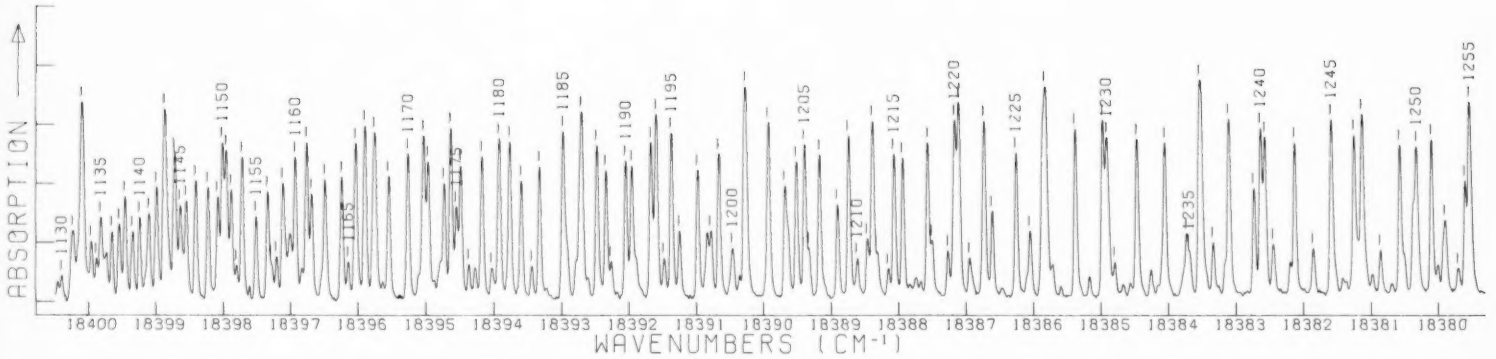
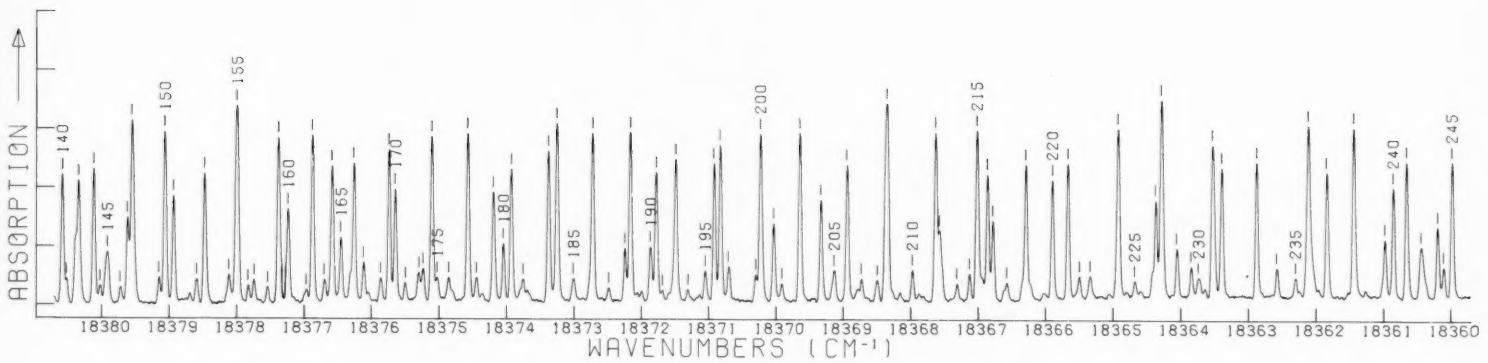
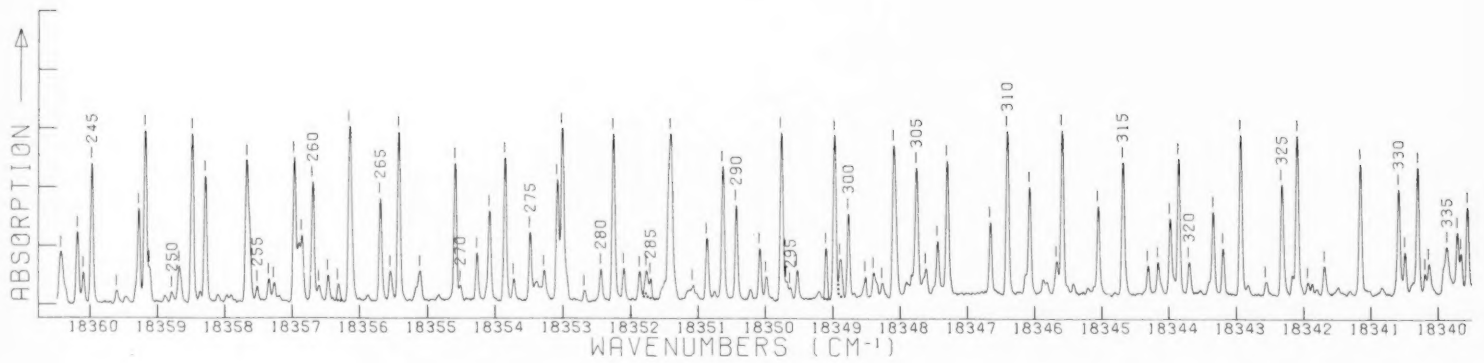
	18419.926	9.929	R 68 (30-1)
1063	18419.653	9.655	P 65 (30-1)
		9.653	P118 (29-0)
		9.646	P104 (35-2)
	18419.577	9.571	R165 (32-0)
1064	18419.428	9.490	P 85 (34-2)
		9.426	P 63 (27-0)
		9.401	R153 (31-0)
1065	18419.181	9.178	P 58 (33-2)
1066	18418.958	8.958	R 61 (33-2)
1067	18418.819	8.819	R 99 (28-0)
		8.798	R 88 (34-2)
1068	18418.385	8.382	R 67 (27-0)
1069	18418.162	8.161	P136 (30-0)
1070	18418.069	8.090	R139 (30-0)
		8.065	P 96 (28-0)
	18417.976	7.978	R 69 (30-1)
	18417.885	7.888	P173 (33-0)
	18417.766	7.767	P 94 (31-1)
		7.766	R 97 (31-1)
	18417.705	7.703	P 66 (30-1)
1071	18417.622	7.619	P 64 (27-0)
	18417.450		
1072	18417.344	7.343	P 59 (33-2)
	18417.121	7.117	R 62 (33-2)
	18416.768	6.766	P 86 (34-2)
1073	18416.562	6.599	R122 (29-0)
		6.557	R 68 (27-0)
	18416.241	6.242	P105 (35-2)
1074	18416.161	6.159	P119 (29-0)
1075	18416.040	6.061	R 89 (34-2)
		6.038	R100 (28-0)
		5.998	R 70 (30-1)
	18415.931	5.928	P163 (32-0)
1076	18415.787	5.785	P 65 (27-0)
		5.721	P 67 (30-1)
1077	18415.471	5.477	P 60 (33-2)
		5.467	P151 (31-0)
		5.425	R176 (33-0)
1078	18415.281	5.281	P 97 (28-0)
		5.245	R 63 (33-2)
	18414.902	4.904	P 95 (31-1)
		4.897	R 98 (31-1)
1079	18414.708	4.717	R154 (31-0)
		4.705	R 69 (27-0)
	18414.384	4.372	R166 (32-0)
1080	18413.927	4.036	P137 (30-0)
		4.010	P 87 (34-2)
		3.988	R 71 (30-1)
		3.955	R140 (30-0)
		3.923	P 66 (27-0)
1081	18413.711	3.710	P 68 (30-1)
1082	18413.580	3.581	P 61 (33-2)
	18413.341	3.342	R 64 (33-2)
	18413.302	3.292	R 90 (34-2)
1083	18413.228	3.228	R101 (28-0)
		3.212	R 1 (29-1)
		3.201	R 2 (29-1)
		3.194	R 0 (29-1)
		3.163	R 3 (29-1)
1084	18413.073	3.097	R 4 (29-1)
		3.073	P 1 (29-1)
		3.071	R123 (29-0)
		3.002	R 5 (29-1)
		2.970	P 2 (29-1)
1085	18412.826	2.879	R 6 (29-1)
		2.839	P 3 (29-1)
		2.825	R 70 (27-0)
		2.805	P106 (35-2)
	18412.725	2.728	R 7 (29-1)
1086	18412.635	2.680	P 4 (29-1)
		2.634	P120 (29-0)
CALC	**********	2.549	R 8 (29-1)
1087	18412.470	2.493	P 5 (29-1)
		2.468	P 98 (28-0)
	18412.339	2.341	R 9 (29-1)
	18412.278	2.278	P 6 (29-1)
	18412.208	2.213	R174 (33-0)
1088	18412.034	2.106	R 10 (29-1)
		2.035	P 7 (29-1)
		2.033	P 67 (27-0)
		2.009	P 96 (31-1)
1089	18411.957	1.997	R 99 (31-1)
		1.949	R 72 (30-1)
	18411.882	1.842	R 11 (29-1)
	18411.761	1.763	P 8 (29-1)
1090	18411.667	1.669	P 69 (30-1)
		1.654	P 62 (33-2)
	18411.547	1.550	R 12 (29-1)
	18411.418	1.463	P 9 (29-1)
		1.409	R 65 (33-2)
1091	18411.225	1.230	R 13 (29-1)
		1.222	P 88 (34-2)
	18411.139	1.135	P 10 (29-1)
1092	18410.918	0.916	R 71 (27-0)
		0.881	R 14 (29-1)
1093	18410.774	0.779	P 11 (29-1)
		0.770	P152 (31-0)
		0.722	P164 (32-0)
	18410.499	0.505	R 15 (29-1)
		0.491	R 91 (34-2)
1094	18410.390	0.394	P 12 (29-1)
		0.389	R102 (28-0)
1095	18410.118	0.115	P 68 (27-0)
		0.100	R 16 (29-1)
	18409.992	0.000	R155 (31-0)
		9.981	P 13 (29-1)
1096	18409.882	9.881	R 73 (30-1)
		9.881	P138 (30-0)
1097	18409.788	9.787	R141 (30-0)
		9.712	R177 (33-0)
1098	18409.627	9.696	P 63 (33-2)
		9.667	R 17 (29-1)
		9.627	P 99 (28-0)
		9.600	P 70 (30-1)
1099	18409.514	9.541	P 14 (29-1)
		9.512	R124 (29-0)
	18409.447	9.445	R 66 (33-2)
	18409.333	9.335	P107 (35-2)
	18409.202	9.205	R 18 (29-1)
1100	18409.078	9.137	R167 (32-0)
		9.084	P 97 (31-1)
		9.080	P121 (29-0)
		9.072	P 15 (29-1)
		9.067	R100 (31-1)
1101	18408.983	8.980	R 72 (27-0)
1102	18408.711	8.716	R 19 (29-1)
	18408.574	8.574	P 16 (29-1)
	18408.400	8.402	P 89 (34-2)
1103	18408.173	8.198	R 20 (29-1)
		8.170	P 69 (27-0)
	18408.049	8.049	P 17 (29-1)
	18407.960		
	18407.900		
	18407.783	7.783	R 74 (30-1)
1104	18407.657	7.707	P 64 (33-2)
		7.658	R 92 (34-2)
		7.652	R 21 (29-1)
1105	18407.517	7.521	R103 (28-0)
		7.501	P 71 (30-1)
		7.495	P 18 (29-1)
		7.449	R 67 (33-2)
1106	18407.018	7.078	R 22 (29-1)
		7.016	R 73 (27-0)
	18406.912	6.913	P 19 (29-1)
1107	18406.756	6.756	P100 (28-0)
1108	18406.479	6.475	R 23 (29-1)
	18406.300	6.303	P 20 (29-1)
1109	18406.199	6.196	P 70 (27-0)
1110	18406.120	6.129	P 98 (31-1)
		6.106	R101 (31-1)
	18406.040	6.039	P153 (31-0)
1111	18405.924	5.923	R125 (29-0)
	18405.839	5.845	R 24 (29-1)
1112	18405.681	5.693	P139 (30-0)
		5.688	P 65 (33-2)
		5.665	P 21 (29-1)
		5.656	R 75 (30-1)
	18405.583	5.587	R142 (30-0)
		5.549	P 90 (34-2)
1113	18405.494	5.495	P122 (29-0)
		5.481	P165 (32-0)
	18405.424	5.423	R 68 (33-2)
	18405.376	5.372	P 72 (30-1)
	18405.266	5.249	R156 (31-0)
1114	18405.186	5.186	R 25 (29-1)
1115	18405.025	5.024	R 74 (27-0)
		4.998	P 22 (29-1)
	18404.817	4.792	R 93 (34-2)
1116	18404.624	4.624	R104 (28-0)
	18404.497	4.498	R 26 (29-1)
	18404.311	4.304	P 23 (29-1)
1117	18404.197	4.195	P 71 (27-0)
	18403.957	3.963	R178 (33-0)
1118	18403.856	3.867	R168 (32-0)
		3.856	P101 (28-0)
1119	18403.789	3.783	R 27 (29-1)
	18403.636	3.637	P 66 (33-2)
	18403.577	3.581	P 24 (29-1)
	18403.499	3.499	R 76 (30-1)
	18403.367	3.366	R 69 (33-2)
	18403.278		
	18403.216	3.214	P 73 (30-1)
	18403.133	3.143	P 99 (31-1)
		3.114	R102 (31-1)
1120	18403.006	3.039	R 28 (29-1)
		3.003	R 75 (27-0)
1121	18402.829	2.829	P 25 (29-1)
1122	18402.687	2.665	P 91 (34-2)
1123	18402.296	2.303	R126 (29-0)
		2.267	R 29 (29-1)
1124	18402.169	2.166	P 72 (27-0)
	18402.066	2.050	P 26 (29-1)
1125	18401.882	1.894	R 94 (34-2)
		1.880	P123 (29-0)
1126	18401.697	1.697	R105 (28-0)
	18401.556	1.556	P 67 (33-2)
1127	18401.467	1.474	P140 (30-0)
		1.467	R 30 (29-1)
CALC	**********	1.356	R143 (30-0)
CALC	**********	1.313	R 77 (30-1)
CALC	**********	1.278	R 70 (33-2)
CALC	**********	1.275	P154 (31-0)
CALC	**********	1.242	P 27 (29-1)
	18401.029	1.027	P 74 (30-1)
1128	18400.949	0.955	R 76 (27-0)
		0.927	P102 (28-0)
	18400.787		
1129	18400.636	0.638	R 31 (29-1)
	18400.466	0.464	R157 (31-0)
1130	18400.405	0.406	P 28 (29-1)
1131	18400.239	0.264	R 1 (26-0)
		0.258	R 2 (26-0)
		0.243	R 0 (26-0)
		0.225	R 3 (26-0)
		0.206	P166 (32-0)
1132	18400.108	0.166	R 4 (26-0)
		0.126	P100 (31-1)
		0.121	P 1 (26-0)
		0.109	P 73 (27-0)
		0.091	R103 (31-1)
		0.079	R 5 (26-0)
		0.019	P 2 (26-0)
1133	18399.967	9.966	R 6 (26-0)
1134	18399.888	9.891	P 3 (26-0)
1135	18399.826	9.826	R 7 (26-0)
		9.781	R 32 (29-1)
	18399.750	9.749	P 92 (34-2)
		9.736	P 4 (26-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
	18400.466	0.464	R157 (31-0)
1130	18400.405	0.406	P 28 (29-1)
1131	18400.239	0.264	R 1 (26-0)
		0.258	R 2 (26-0)
		0.243	R 0 (26-0)
		0.225	R 3 (26-0)
		0.206	P166 (32-0)
1132	18400.108	0.166	R 4 (26-0)
		0.126	P100 (31-1)
		0.121	P 1 (26-0)
		0.109	P 73 (27-0)
		0.091	R103 (31-1)
		0.079	R 5 (26-0)
		0.019	P 2 (26-0)
1133	18399.967	9.966	R 6 (26-0)
1134	18399.888	9.891	P 3 (26-0)
1135	18399.826	9.826	R 7 (26-0)
		9.781	R 32 (29-1)
	18399.750	9.749	P 92 (34-2)
		9.736	P 4 (26-0)
1136	18399.658	9.659	R 8 (26-0)
1137	18399.550	9.554	P 5 (26-0)
		9.542	P 29 (29-1)
1138	18399.464	9.465	R 9 (26-0)
		9.444	P 68 (33-2)
1139	18399.349	9.345	P 6 (26-0)
1140	18399.246	9.244	R 10 (26-0)
1141	18399.108	9.159	R 71 (33-2)
		9.109	P 7 (26-0)
		9.097	R 78 (30-1)
1142	18398.996	8.997	R 11 (26-0)
		8.964	R 95 (34-2)
1143	18398.880	8.896	R 33 (29-1)
		8.879	R 77 (27-0)
		8.847	P 8 (26-0)
		8.811	P 75 (30-1)
1144	18398.731	8.741	R106 (28-0)
		8.722	R 12 (26-0)
1145	18398.652	8.653	R127 (29-0)
		8.649	P 30 (29-1)
1146	18398.559	8.563	R169 (32-0)
		8.557	P 9 (26-0)
1147	18398.420	8.421	R 13 (26-0)
1148	18398.239	8.241	P 10 (26-0)
		8.235	P124 (29-0)
		8.176	R179 (33-0)
1149	18398.092	8.093	R 14 (26-0)
1150	18398.027	8.024	P 74 (27-0)
1151	18397.974	7.982	R 34 (29-1)
		7.969	P103 (28-0)
1152	18397.898	7.898	P 11 (26-0)
1153	18397.822		
1154	18397.736	7.738	R 15 (26-0)
		7.729	P 31 (29-1)
1155	18397.527	7.528	P 12 (26-0)
1156	18397.355	7.356	R 16 (26-0)
1157	18397.302	7.301	P 69 (33-2)
1158	18397.224	7.223	P141 (30-0)
1159	18397.130	7.131	P 13 (26-0)
	18397.025	7.092	R144 (30-0)
		7.079	P101 (31-1)
		7.040	R 35 (29-1)
		7.037	R104 (31-1)
		7.008	R 72 (33-2)
1160	18396.947	6.947	R 17 (26-0)
	18396.850	6.852	R 79 (30-1)
1161	18396.778	6.800	P 93 (34-2)
		6.779	P 32 (29-1)
		6.775	R 78 (27-0)
1162	18396.707	6.707	P 14 (26-0)
1163	18396.510	6.565	P 76 (30-1)
		6.511	R 18 (26-0)
		6.478	P155 (31-0)
1164	18396.257	6.257	P 15 (26-0)
1165	18396.163		
1166	18396.051	6.070	R 36 (29-1)
		6.048	R 19 (26-0)
		6.001	R 96 (34-2)
1167	18395.914	5.911	P 75 (27-0)
1168	18395.770	5.802	P 33 (29-1)
		5.779	P 16 (26-0)
		5.756	R107 (28-0)
	18395.649	5.646	R158 (31-0)
1169	18395.559	5.559	R 20 (26-0)
1170	18395.276	5.275	P 17 (26-0)
1171	18395.045	5.127	P 70 (33-2)
		5.071	R 37 (29-1)
		5.043	R 21 (26-0)
1172	18394.981	4.982	P104 (28-0)
		4.972	R128 (29-0)
	18394.894	4.895	P167 (32-0)
	18394.806	4.827	R 73 (33-2)
		4.796	P 34 (29-1)
1173	18394.745	4.744	P 18 (26-0)
1174	18394.645	4.643	R 79 (27-0)
1175	18394.563	4.577	R 80 (30-1)
		4.559	P125 (29-0)
1176	18394.500	4.499	R 22 (26-0)
1177	18394.382		
	18394.292	4.289	P 77 (30-1)
1178	18394.186	4.186	P 19 (26-0)
1179	18394.043	4.044	R 38 (29-1)
		4.000	P102 (31-1)
1180	18393.930	3.953	R105 (31-1)
		3.929	R 23 (26-0)
1181	18393.771	3.819	P 94 (34-2)
		3.771	P 76 (27-0)
		3.762	P 35 (29-1)
1182	18393.601	3.601	P 20 (26-0)
1183	18393.447		
1184	18393.332	3.332	R 24 (26-0)
	18393.228	3.222	R170 (32-0)
1185	18392.989	3.006	R 97 (34-2)
		2.989	P 21 (26-0)
		2.989	R 39 (29-1)
		2.940	P142 (30-0)
		2.922	P 71 (33-2)
	18392.795	2.797	R145 (30-0)
		2.742	R108 (28-0)
1186	18392.712	2.708	R 25 (26-0)
		2.700	P 36 (29-1)
	18392.618	2.615	R 74 (33-2)
1187	18392.485	2.483	R 80 (27-0)
1188	18392.350	2.353	R180 (33-0)
		2.350	P 22 (26-0)
1189	18392.275	2.272	R 81 (30-1)
1190	18392.056	2.057	R 26 (26-0)
1191	18391.968	1.984	P 78 (30-1)
		1.966	P105 (28-0)
		1.905	R 40 (29-1)
1192	18391.685	1.685	P 23 (26-0)
		1.647	P156 (31-0)
1193	18391.606	1.609	P 37 (29-1)
		1.602	P 77 (27-0)
1194	18391.489		
1195	18391.379	1.379	R 27 (26-0)
1196	18391.261	1.260	R129 (29-0)
1197	18390.992	0.992	P 24 (26-0)
CALC	**********	0.891	P103 (31-1)
CALC	**********	0.853	P126 (29-0)
CALC	**********	0.837	R106 (31-1)
CALC	**********	0.806	P 95 (34-2)
1198	18390.797	0.794	R159 (31-0)
		0.793	R 41 (29-1)
1199	18390.676	0.686	P 72 (33-2)
		0.675	R 28 (26-0)
1200	18390.475	0.491	P 38 (29-1)
	18390.374	0.372	R 75 (33-2)
1201	18390.285	0.294	R 81 (27-0)
		0.273	P 25 (26-0)
1202	18389.943	9.979	R 98 (34-2)
		9.943	R 29 (26-0)
		9.938	R 82 (30-1)
1203	18389.698	9.698	R109 (28-0)
		9.652	R 42 (29-1)
		9.650	P 79 (30-1)
1204	18389.528	9.550	P168 (32-0)
		9.526	P 26 (26-0)
1205	18389.409	9.405	P 78 (27-0)
1206	18389.350	9.343	P 39 (29-1)
1207	18389.185	9.184	R 30 (26-0)
1208	18388.920	8.921	P106 (28-0)
1209	18388.754	8.753	P 27 (26-0)
1210	18388.627	8.625	P143 (30-0)
1211	18388.477	8.483	R 43 (29-1)
		8.469	R146 (30-0)
1212	18388.400	8.420	P 73 (33-2)
		8.399	R 31 (26-0)
1213	18388.336		
1214	18388.166	8.168	P 40 (29-1)
1215	18388.081	8.097	R 76 (33-2)
		8.078	R 82 (27-0)
1216	18387.953	7.953	P 28 (26-0)
	18387.850	7.847	R171 (32-0)
	18387.763	7.761	P 96 (34-2)
		7.752	P104 (31-1)
	18387.693	7.691	R107 (31-1)
1217	18387.586	7.586	R 32 (26-0)
		7.574	R 83 (30-1)
1218	18387.521	7.518	R130 (29-0)
1219	18387.285	7.286	R 44 (29-1)
		7.286	P 80 (30-1)
1220	18387.184	7.181	P 79 (27-0)
1221	18387.125	7.126	P 29 (26-0)
		7.116	R127 (29-0)
1222	18386.964	6.964	P 81 (29-1)
		6.919	R 99 (34-2)
1223	18386.747	6.783	P157 (31-0)
		6.747	R 33 (26-0)
1224	18386.625	6.625	R110 (28-0)
	18386.483	6.492	R181 (33-0)
1225	18386.273	6.272	P 30 (26-0)
1226	18386.067	6.122	P 74 (33-2)
		6.060	R 45 (29-1)
1227	18385.844	5.908	R160 (31-0)
		5.880	R 34 (26-0)
		5.846	P107 (28-0)
		5.833	R 83 (27-0)
		5.792	R 77 (33-2)
	18385.735	5.731	P 42 (29-1)
1228	18385.391	5.391	P 31 (26-0)
	18385.183	5.181	R 84 (30-1)
1229	18384.987	4.987	R 35 (26-0)
1230	18384.929	4.928	P 80 (27-0)
		4.892	P 81 (30-1)
1231	18384.808	4.806	R 46 (29-1)
	18384.688	4.683	P 97 (34-2)
	18384.583	4.581	P105 (31-1)
1232	18384.482	4.513	R108 (31-1)
		4.484	P 32 (26-0)
		4.471	P 43 (29-1)
	18384.281	4.279	P144 (30-0)
1233	18384.068	4.169	P169 (32-0)
		4.109	R147 (30-0)
		4.066	R 36 (26-0)
1234	18383.745	3.827	R100 (34-2)
		3.793	P 75 (33-2)
		3.745	R131 (29-0)
1235	18383.709		
1236	18383.547	3.561	R 84 (27-0)
		3.549	P 33 (26-0)
		3.523	R 47 (29-1)
		3.523	R111 (28-0)
		3.455	R 78 (33-2)
1237	18383.348	3.349	P128 (29-0)
1238	18383.120	3.181	P 44 (29-1)
		3.119	R 37 (26-0)
1239	18382.746	2.757	R 85 (30-1)
		2.742	P108 (28-0)
1240	18382.649	2.647	P 81 (27-0)
1241	18382.588	2.587	P 34 (26-0)
1242	18382.466	2.469	P 82 (30-1)
		2.436	R172 (32-0)
	18382.214	2.212	R 48 (29-1)
1243	18382.145	2.144	R 38 (26-0)
1244	18381.869	1.886	P158 (31-0)
		1.864	P 45 (29-1)
1245	18381.600	1.599	P 35 (26-0)
		1.573	P 98 (34-2)
	18381.434	1.433	P 76 (33-2)
	18381.388	1.380	P106 (31-1)
1246	18381.261	1.305	R109 (31-1)
		1.260	R 85 (27-0)
1247	18381.144	1.143	R 39 (26-0)
		1.087	R 79 (33-2)
	18380.998	0.989	R161 (31-0)
1248	18380.871	0.873	R 49 (29-1)
	18380.705	0.702	R101 (34-2)
1249	18380.583	0.583	P 36 (26-0)
		0.518	P 46 (29-1)
1250	18380.341	0.391	R112 (28-0)
		0.339	F 82 (27-0)
		0.304	R 86 (30-1)
1251	18380.115	0.115	R 40 (26-0)
	18380.021	0.017	P 83 (30-1)
1252	18379.911	9.941	R132 (29-0)
		9.900	P145 (30-0)
1253	18379.714	9.717	R148 (30-0)
1254	18379.609	9.609	P109 (28-0)
1255	18379.543	9.551	P129 (29-0)
		9.540	P 37 (26-0)
		9.505	R 50 (29-1)



LINE	OBS CM-1	CALC	ASSIGNMENT
140	18380.583	0.583	P 36 (26-0)
141	18380.523	0.518	P 46 (29-1)
142	18380.341	0.391	R112 (28-0)
		0.339	P 82 (27-0)
		0.304	R 86 (30-1)
143	18380.115	0.115	R 40 (26-0)
144	18380.020	0.017	P 83 (30-1)
145	18379.911	9.941	R132 (29-0)
		9.900	P145 (30-0)
146	18379.716	9.717	R148 (30-0)
147	18379.608	9.609	P109 (28-0)
148	18379.542	9.551	P129 (29-0)
		9.540	P 37 (26-0)
		9.505	R 50 (29-1)
149	18379.145	9.144	P 47 (29-1)
150	18379.059	9.059	R 41 (26-0)
		9.042	P 77 (33-2)
151	18378.931	8.931	R 86 (27-0)
	18378.754	8.754	P170 (32-0)
	18378.693	8.688	R 80 (33-2)
152	18378.589		
153	18378.470	8.471	P 38 (26-0)
		8.431	P 99 (34-2)
154	18378.111	8.148	P107 (31-1)
		8.108	R 51 (29-1)
		8.065	R110 (31-1)
155	18377.990	8.002	P 83 (27-0)
		7.977	R 42 (26-0)
156	18377.823	7.822	R 87 (30-1)
157	18377.739	7.741	P 48 (29-1)
158	18377.536	7.545	R102 (34-2)
		7.535	P 84 (30-1)
159	18377.373	7.374	P 39 (26-0)
160	18377.230	7.230	R113 (28-0)
161	18376.961	6.989	R173 (32-0)
		6.955	P159 (31-0)
162	18376.868	6.867	R 43 (26-0)
163	18376.685	6.683	R 52 (29-1)
164	18376.574	6.621	P 78 (33-2)
		6.574	R 87 (27-0)
165	18376.446	6.447	P110 (28-0)
166	18376.250	6.310	P 49 (29-1)
		6.257	R 81 (33-2)
		6.251	P 40 (26-0)
167	18376.105	6.107	R133 (29-0)
	18376.041	6.036	R162 (31-0)
168	18375.855		
169	18375.731	5.731	R 44 (26-0)
		5.723	P130 (29-0)
170	18375.638	5.637	P 84 (27-0)
171	18375.492	5.490	P146 (30-0)
172	18375.296	5.310	R 88 (30-1)
		5.292	R149 (30-0)
173	18375.231	5.256	P100 (34-2)
		5.229	R 53 (29-1)
174	18375.100	5.100	P 41 (26-0)
175	18375.018	5.023	P 85 (30-1)
176	18374.852	4.885	P108 (31-1)
		4.850	P 50 (29-1)
	18374.800	4.795	R111 (31-1)
177	18374.568	4.567	R 45 (26-0)
178	18374.439		
	18374.356	4.355	R103 (34-2)
179	18374.187	4.188	R 88 (27-0)
		4.167	P 79 (33-2)
180	18374.038	4.039	R114 (28-0)
181	18373.922	3.923	P 42 (26-0)
182	18373.748	3.796	R 82 (33-2)
		3.747	R 54 (29-1)
183	18373.375	3.376	R 46 (26-0)
		3.362	P 51 (29-1)
184	18373.248	3.303	P171 (32-0)
		3.255	P111 (28-0)
		3.244	P 85 (27-0)
185	18373.001		
186	18372.718	2.767	R 89 (30-1)
		2.718	P 43 (26-0)
187	18372.479	2.481	P 86 (30-1)
188	18372.240	2.242	R134 (29-0)
		2.237	R 55 (29-1)
189	18372.159	2.159	R 47 (26-0)
	18372.053	2.049	P101 (34-2)
	18371.992	1.991	P160 (31-0)
190	18371.858	1.864	P131 (29-0)
		1.845	P 52 (29-1)
191	18371.774	1.774	R 89 (27-0)
192	18371.684	1.683	P 80 (33-2)
193	18371.487	1.591	P109 (31-1)
		1.507	R174 (32-0)
		1.493	R112 (31-1)
		1.487	P 44 (26-0)
194	18371.303	1.303	R 83 (33-2)
	18371.136	1.132	R104 (34-2)
195	18371.048	1.049	R163 (31-0)
		1.047	P147 (30-0)
196	18370.915	0.914	R 48 (26-0)
197	18370.822	0.836	R150 (30-0)
		0.823	P 86 (27-0)
		0.819	R115 (28-0)
198	18370.696	0.697	R 56 (29-1)
199	18370.300	0.300	P 53 (29-1)
200	18370.228	0.228	P 45 (26-0)
		0.195	R 90 (30-1)
201	18370.032	0.034	P112 (28-0)
202	18369.910	9.910	P 87 (30-1)
203	18369.643	9.642	R 49 (26-0)
204	18369.331	9.332	R 90 (27-0)
205	18369.132	9.168	P 81 (33-2)
		9.130	R 57 (29-1)
206	18368.942	8.943	P 46 (26-0)
	18368.787	8.810	P102 (34-2)
		8.779	R 84 (33-2)
207	18368.728	8.727	P 54 (29-1)
208	18368.495		
209	18368.353	8.373	P 87 (27-0)
		8.345	R135 (29-0)
		8.343	R 50 (26-0)
		8.266	P110 (31-1)
	18368.159	8.160	R113 (31-1)
210	18367.973	7.975	P132 (29-0)
	18367.878	7.877	R105 (34-2)
	18367.815	7.817	P172 (32-0)
211	18367.629	7.630	P 47 (26-0)
212	18367.573	7.594	R 91 (30-1)
		7.569	R116 (28-0)
		7.533	R 58 (29-1)
213	18367.310	7.309	P 88 (30-1)
214	18367.126	7.125	P 55 (29-1)
215	18367.016	7.017	R 51 (26-0)
		6.993	P161 (31-0)
216	18366.861	6.862	R 91 (27-0)
217	18366.781	6.784	P113 (28-0)
218	18366.573	6.621	P 82 (33-2)
		6.573	P148 (30-0)
219	18366.291	6.347	R151 (30-0)
		6.291	P 48 (26-0)
		6.223	R 85 (33-2)
	18366.023	6.027	R164 (31-0)
		5.989	R175 (32-0)
220	18365.897	5.908	R 59 (29-1)
		5.896	P 88 (27-0)
221	18365.663	5.664	R 52 (26-0)
222	18365.492	5.538	P103 (34-2)
		5.494	P 56 (29-1)
223	18365.334		
	18365.052		
224	18364.925	4.962	R 92 (30-1)
		4.924	P 49 (26-0)
		4.910	P111 (31-1)
	18364.795	4.796	R114 (31-1)
225	18364.677	4.679	P 89 (30-1)
	18364.588	4.589	R106 (34-2)
226	18364.364	4.418	R136 (29-0)
		4.364	R 92 (27-0)
227	18364.282	4.289	R117 (28-0)
		4.283	R 53 (26-0)
		4.255	R 60 (29-1)
228	18364.051	4.054	P133 (29-0)
		4.044	P 83 (33-2)
229	18363.835	3.835	P 57 (29-1)
230	18363.725		
	18363.639	3.636	R 86 (33-2)
231	18363.526	3.530	P 50 (26-0)
		3.505	P114 (28-0)
232	18363.389	3.390	P 89 (27-0)
233	18362.876	2.876	R 54 (26-0)
234	18362.573	2.572	R 61 (29-1)
235	18362.296	2.300	R 93 (30-1)
	18362.234	2.233	P104 (34-2)
236	18362.108	2.148	P 58 (29-1)
		2.109	P 51 (26-0)
		2.066	P149 (30-0)
		2.018	P 90 (30-1)
	18361.963	1.961	P162 (31-0)
237	18361.835	1.837	R 93 (27-0)
		1.825	R152 (30-0)
	18361.524	1.523	P112 (31-1)
238	18361.442	1.441	R 55 (26-0)
		1.435	P 84 (33-2)
		1.400	R115 (31-1)
	18361.265	1.269	R107 (34-2)
239	18360.978	1.018	R 87 (33-2)
		0.980	R118 (28-0)
		0.972	R165 (31-0)
240	18360.856	0.861	R 62 (29-1)
		0.857	P 90 (27-0)
241	18360.661	0.661	P 52 (26-0)
242	18360.440	0.460	R137 (29-0)
		0.435	R176 (32-0)
		0.431	P 59 (29-1)
243	18360.195	0.195	P115 (28-0)
244	18360.104	0.103	P134 (29-0)
245	18359.979	9.979	R 56 (26-0)



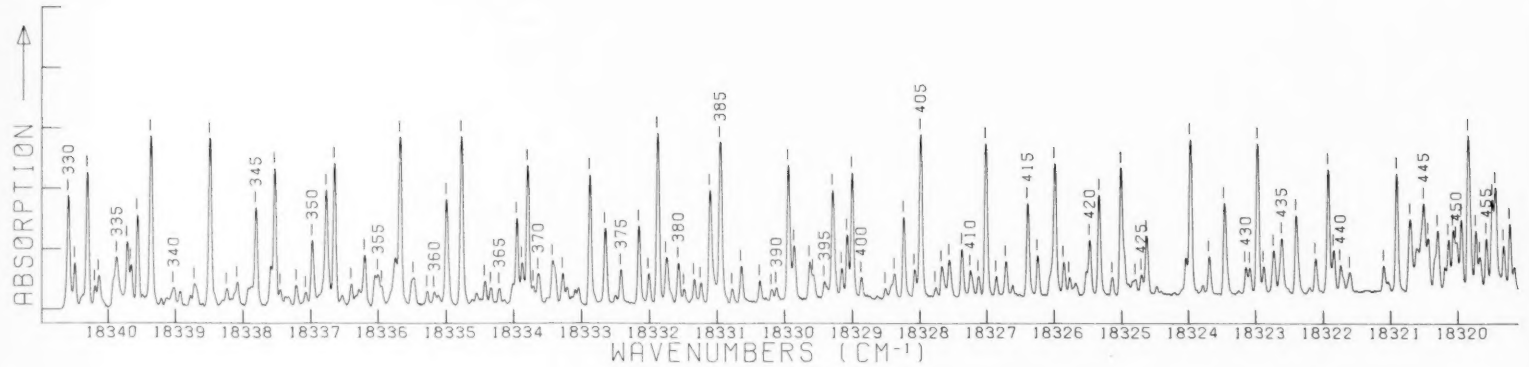
LINE	OBS CM-1	CALC	ASSIGNMENT
242	18360.440	0.460	R137 (29-0)
		0.435	R176 (32-0)
		0.431	P 59 (29-1)
243	18360.195	0.195	P115 (28-0)
244	18360.104	0.103	P134 (29-0)
245	18359.979	9.979	R 56 (26-0)
246	18359.606	9.609	R 94 (30-1)
247	18359.282	9.328	P 91 (30-1)
		9.282	R 94 (27-0)
248	18359.187	9.186	P 53 (26-0)
249	18359.124	9.122	R 63 (29-1)
	18358.896	8.896	P105 (34-2)
250	18358.792	8.794	P 85 (33-2)
251	18358.685	8.687	P 60 (29-1)
252	18358.490	8.490	R 57 (26-0)
CALC	*********	8.368	R 88 (33-2)
253	18358.293	8.295	P 91 (27-0)
	18358.103	8.105	P113 (31-1)
	18357.973	7.974	R116 (31-1)
	18357.911	7.915	R108 (34-2)
254	18357.683	7.684	P 54 (26-0)
		7.642	R119 (28-0)
255	18357.526	7.527	P150 (30-0)
256	18357.351	7.354	R 64 (29-1)
257	18357.273	7.271	R153 (30-0)
258	18356.973	6.974	R 58 (26-0)
259	18356.859	6.913	P 61 (29-1)
		6.896	P163 (31-0)
		6.887	R 95 (30-1)
		6.857	P116 (28-0)
260	18356.698	6.698	R 95 (27-0)
261	18356.608	6.609	P 92 (30-1)
262	18356.469	6.471	R138 (29-0)
263	18356.321	*****	ARTIFACT

LINE	OBS CM-1	CALC	ASSIGNMENT
264	18356.152	6.155	P 55 (26-0)
		6.123	P 86 (33-2)
		6.122	P135 (29-0)
	18355.885	5.883	R166 (31-0)
265	18355.702	5.704	P 92 (27-0)
		5.687	R 89 (33-2)
266	18355.555	5.557	R 65 (29-1)
		5.526	P106 (34-2)
267	18355.431	5.431	R 59 (26-0)
268	18355.118	5.111	P 62 (29-1)
	18354.843	4.846	R177 (32-0)
269	18354.598	4.655	P114 (31-1)
		4.598	P 56 (26-0)
270	18354.520	4.516	R117 (31-1)
271	18354.272	4.274	R120 (28-0)
272	18354.086	4.136	R 96 (30-1)
		4.086	R 96 (27-0)
273	18353.858	3.860	R 60 (26-0)
		3.859	P 93 (30-1)
274	18353.730	3.731	R 66 (29-1)
275	18353.488	3.489	P117 (28-0)
	18353.394	3.420	P 87 (33-2)
	18353.345		
276	18353.280	3.281	P 63 (29-1)
277	18353.086	3.086	P 93 (27-0)
278	18353.015	3.015	P 57 (26-0)
		2.974	R 90 (33-2)
		2.956	P151 (30-0)
279	18352.684	2.684	R154 (30-0)
280	18352.449	2.450	R139 (29-0)
281	18352.262	2.262	R 61 (26-0)
282	18352.109	2.124	P107 (34-2)
		2.109	P136 (29-0)
283	18351.876	1.877	R 67 (29-1)
CALC	*********	1.796	P164 (31-0)
284	18351.771	*****	ARTIFACT

LINE	OBS CM-1	CALC	ASSIGNMENT
285	18351.712	*****	ARTIFACT
286	18351.410	1.446	R 97 (27-0)
		1.421	P 64 (29-1)
		1.404	P 58 (26-0)
		1.355	R 97 (30-1)
		1.175	P115 (31-1)
287	18351.081	1.079	P 94 (30-1)
	18351.039	1.026	R118 (31-1)
288	18350.874	0.876	R121 (28-0)
	18350.761	0.759	R167 (31-0)
289	18350.637	0.686	P 88 (33-2)
		0.637	R 62 (26-0)
290	18350.437	0.439	P 94 (27-0)
	18350.232	0.230	R 91 (33-2)
291	18350.087	0.091	P118 (28-0)
292	18349.993	9.993	R 68 (29-1)
293	18349.767	9.766	P 59 (26-0)
294	18349.694		
295	18349.636		
296	18349.534	9.533	P 65 (29-1)
	18349.214	9.220	R178 (32-0)
297	18349.109	*****	ARTIFACT
298	18348.984	8.985	R 63 (26-0)
299	18348.896	*****	ARTIFACT
300	18348.776	8.777	R 98 (27-0)
	18348.689	8.689	P108 (34-2)
301	18348.523	8.543	R 98 (30-1)
302	18348.395	8.399	R140 (29-0)
		8.352	P152 (30-0)
303	18348.266	8.270	P 95 (30-1)
304	18348.096	8.101	P 60 (26-0)
		8.082	R 69 (29-1)
		8.066	P137 (29-0)
		8.065	R155 (30-0)
	18347.917	7.920	P 89 (33-2)
305	18347.761	7.764	P 95 (27-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
306	18347.620	7.663	P116 (31-1)
		7.617	P 66 (29-1)
307	18347.448	7.506	R119 (31-1)
		7.454	R 92 (33-2)
		7.448	R122 (28-0)
308	18347.305	7.305	R 64 (26-0)
309	18346.661	6.664	P119 (28-0)
		6.663	P165 (31-0)
310	18346.408	6.409	P 61 (26-0)
311	18346.079	6.141	R 70 (29-1)
		6.080	R 99 (27-0)
	18345.878		
	18345.822		
312	18345.677	5.702	R 99 (30-1)
		5.672	P 67 (29-1)
313	18345.598	5.601	R168 (31-0)
		5.598	R 65 (26-0)
	18345.431	5.431	P 96 (30-1)
	18345.218	5.221	P109 (34-2)
314	18345.060	5.123	P 90 (33-2)
		5.061	P 96 (27-0)
315	18344.689	4.689	P 62 (26-0)
		4.647	R 93 (33-2)
316	18344.314	4.317	R141 (29-0)
317	18344.168	4.171	R 71 (29-1)
		4.121	P117 (31-1)
318	18343.989	3.991	P138 (29-0)
		3.990	R123 (28-0)
		3.953	R120 (31-1)
319	18343.864	3.864	R 66 (26-0)
320	18343.705	3.717	P153 (30-0)
		3.698	P 68 (29-1)
	18343.552	3.559	R179 (32-0)
321	18343.352	3.413	R156 (30-0)
		3.354	R100 (27-0)
322	18343.203	3.208	P120 (28-0)
323	18342.943	2.943	P 63 (26-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
		18342.829	2.830	R100 (30-1)
324	18342.562	2.562	P 97 (30-1)
325	18342.326	2.329	P 97 (27-0)
		2.295	P 91 (33-2)
326	18342.101	2.173	R 72 (29-1)
		2.102	R 67 (26-0)
327	18341.942		
		18341.879		
		18341.809	1.808	R 94 (33-2)
	18341.697	1.695	P 69 (29-1)
		18341.494	1.496	P166 (31-0)
329	18341.168	1.169	P 64 (26-0)
		18340.849		
330	18340.598	0.600	R101 (27-0)
331	18340.502	0.547	P118 (31-1)
		0.503	R124 (28-0)
332	18340.313	0.409	R169 (31-0)
		0.370	R121 (31-1)
		0.314	R 68 (26-0)
333	18340.201	0.203	R142 (29-0)
334	18340.143	0.146	R 73 (29-1)
335	18339.879	9.929	R101 (30-1)
		9.886	P139 (29-0)
		9.859	R 1 (28-1)
		9.850	R 2 (28-1)
		9.840	R 0 (28-1)
		9.814	R 3 (28-1)
336	18339.719	9.750	R 4 (28-1)
		9.721	P121 (28-0)
		9.719	P 1 (28-1)
337	18339.663	9.664	P 70 (29-1)
		9.662	P 98 (30-1)
		9.659	R 5 (28-1)
		9.617	P 2 (28-1)
338	18339.566	9.569	P 98 (27-0)
		9.540	R 6 (28-1)



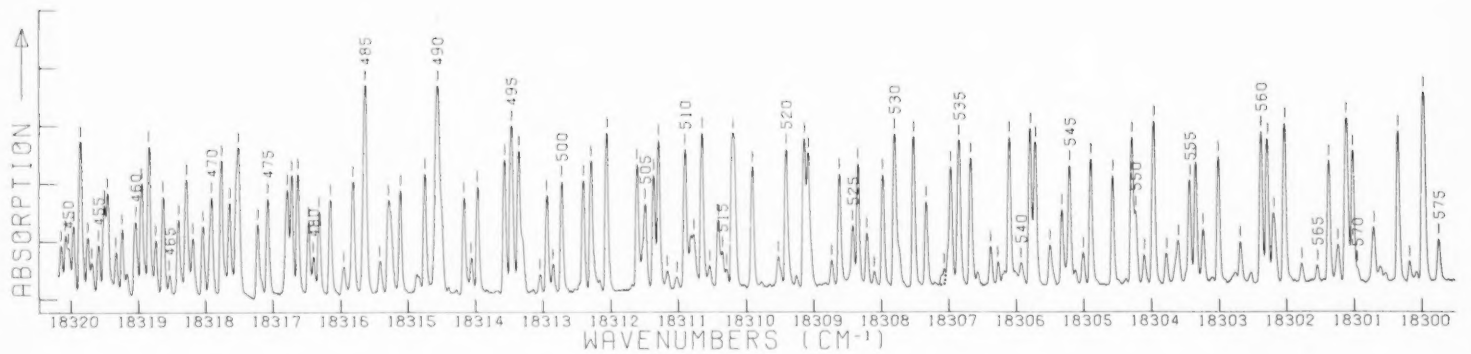
LINE	OBS CM-1	CALC	ASSIGNMENT
330	18340.598	0.600	R101 (27-0)
331	18340.502	0.547	P118 (31-1)
		0.503	R124 (28-0)
332	18340.313	0.409	R169 (31-0)
		0.370	R121 (31-1)
		0.314	R 68 (26-0)
333	18340.201	0.203	R142 (29-0)
334	18340.143	0.146	R 73 (29-1)
335	18339.879	9.929	R101 (30-1)
		9.886	P139 (29-0)
		9.859	R 1 (28-1)
		9.850	R 2 (28-1)
		9.840	R 0 (28-1)
		9.814	R 3 (28-1)
336	18339.719	9.750	R 4 (28-1)
		9.721	P121 (28-0)
		9.719	P 1 (28-1)
337	18339.663	9.664	P 70 (29-1)
		9.662	P 98 (30-1)
		9.659	R 5 (28-1)
		9.617	P 2 (28-1)
338	18339.566	9.569	P 98 (27-0)
		9.540	R 6 (28-1)
	18339.484	9.487	P 3 (28-1)
339	18339.368	9.435	P 92 (33-2)
		9.393	R 7 (28-1)
		9.368	P 65 (26-0)
		9.330	P 4 (28-1)
	18339.220	9.219	R 8 (28-1)
	18339.134	9.145	P 5 (28-1)
340	18339.030	9.048	P154 (30-0)
		9.016	R 9 (28-1)
	18338.937	8.938	R 95 (33-2)
		8.932	P 6 (28-1)
	18338.786	8.787	R 10 (28-1)
341	18338.726	8.729	R157 (30-0)
		8.692	P 7 (28-1)
342	18338.498	8.529	R 11 (28-1)
		8.497	R 69 (26-0)
		8.424	P 8 (28-1)
343	18338.247	8.244	R 12 (28-1)
344	18338.092	8.128	P 9 (28-1)
		8.090	R 74 (29-1)
345	18337.815	7.932	R 13 (28-1)
		7.817	R102 (27-0)
		7.805	P 10 (28-1)
	18337.600	7.604	P 71 (29-1)
		7.591	R 14 (28-1)
346	18337.539	7.539	P 66 (26-0)
347	18337.458	7.454	P 11 (28-1)
	18337.378		

LINE	OBS CM-1	CALC	ASSIGNMENT
	18337.337		
348	18337.222	7.223	R 15 (28-1)
349	18337.083	7.076	P 12 (28-1)
350	18336.985	6.997	R102 (30-1)
		6.986	R125 (28-0)
		6.941	P119 (31-1)
351	18336.779	6.827	R 16 (28-1)
		6.780	P 99 (27-0)
		6.755	R122 (31-1)
		6.733	P 99 (30-1)
352	18336.655	6.669	P 13 (28-1)
		6.654	R 70 (26-0)
	18336.540	6.544	P 93 (33-2)
353	18336.403	6.404	R 17 (28-1)
	18336.290	6.295	P167 (31-0)
354	18336.204	6.235	P 14 (28-1)
		6.205	P122 (28-0)
355	18336.008	6.058	R143 (29-0)
		6.036	R 96 (33-2)
		6.005	R 75 (29-1)
356	18335.952	5.953	R 18 (28-1)
	18335.753	5.774	P 15 (28-1)
		5.750	P140 (29-0)
357	18335.684	5.684	P 67 (26-0)
358	18335.481	5.515	P 72 (29-1)
		5.474	R 19 (28-1)
359	18335.284	5.285	P 16 (28-1)
360	18335.181	5.183	R170 (31-0)
	18335.122		
361	18335.002	5.005	R103 (27-0)
		4.968	R 20 (28-1)
362	18334.781	4.783	R 71 (26-0)
		4.768	P 17 (28-1)
	18334.617		
	18334.554		
363	18334.435	4.433	R 21 (28-1)
364	18334.346	4.348	P155 (30-0)
365	18334.222	4.223	P 18 (28-1)
	18334.147	4.035	R103 (30-1)
366	18333.960	4.012	R158 (30-0)
		3.963	P100 (27-0)
367	18333.884	3.891	R 76 (29-1)
		3.871	R 22 (28-1)
368	18333.799	3.801	P 68 (26-0)
		3.774	P100 (30-1)
369	18333.714		
370	18333.645	3.651	P 19 (28-1)
		3.621	P 94 (33-2)
371	18333.434	3.439	R126 (28-0)
		3.397	P 73 (29-1)

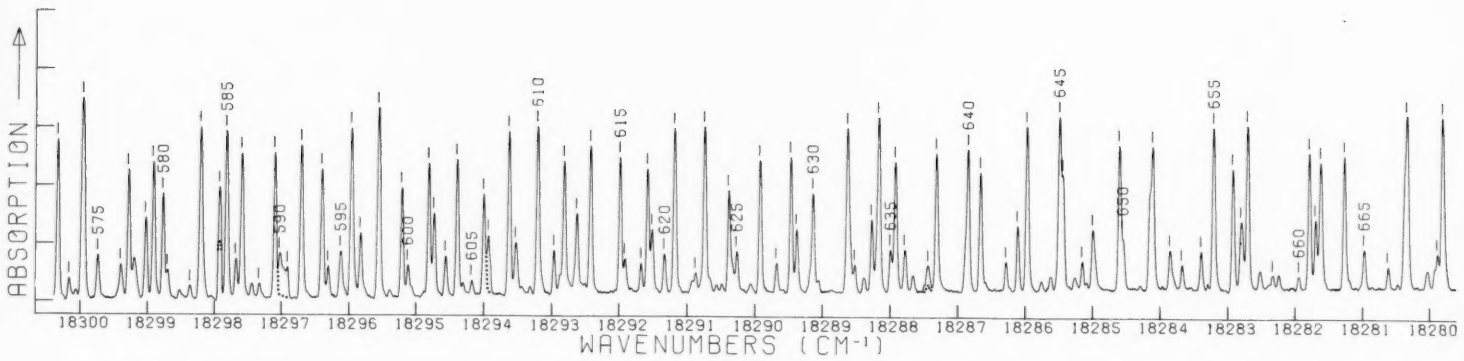
LINE	OBS CM-1	CALC	ASSIGNMENT
372	18333.285	3.304	P120 (31-1)
		3.282	R 23 (28-1)
	18333.221		
	18333.103	3.108	R123 (31-1)
		3.102	R 97 (33-2)
	18333.056	3.051	P 20 (28-1)
373	18332.884	2.885	R 72 (26-0)
374	18332.659	2.665	R 24 (28-1)
		2.660	P123 (28-0)
	18332.509		
375	18332.428	2.424	P 21 (28-1)
376	18332.163	2.165	R104 (27-0)
377	18332.021	2.019	R 25 (28-1)
378	18331.889	1.890	P 69 (26-0)
		1.882	R144 (29-0)
379	18331.758	1.769	P 22 (28-1)
		1.749	R 77 (29-1)
380	18331.582	1.583	P141 (29-0)
381	18331.498		
382	18331.349	1.347	R 26 (28-1)
383	18331.251	1.251	P 74 (29-1)
384	18331.114	1.118	P101 (27-0)
		1.086	P 23 (28-1)
		1.060	P168 (31-0)
		1.043	R104 (30-1)
		0.959	R 73 (26-0)
385	18330.959	0.785	P101 (30-1)
386	18330.782	0.667	P 95 (33-2)
387	18330.650	0.646	R 27 (28-1)
		0.375	P 24 (28-1)
388	18330.377		
389	18330.200	0.136	R 98 (33-2)
390	18330.126	9.953	P 70 (26-0)
391	18329.952	9.922	R171 (31-0)
		9.918	R 28 (28-1)
392	18329.863	9.862	R127 (28-0)
393	18329.633	9.637	P 25 (28-1)
		9.636	P121 (31-1)
		9.615	P156 (30-0)
394	18329.582	9.577	R 78 (29-1)
395	18329.418	9.429	R124 (31-1)
396	18329.293	9.297	R105 (27-0)
		9.261	R159 (30-0)
397	18329.161	9.162	R 29 (28-1)
398	18329.079	9.085	P124 (28-0)
		9.076	P 75 (29-1)
399	18329.005	9.006	R 74 (26-0)
400	18328.871	8.871	P 26 (28-1)
401	18328.517		
402	18328.380	8.378	R 30 (28-1)

LINE	OBS CM-1	CALC	ASSIGNMENT
403	18328.240	8.244	P102 (27-0)
404	18328.077	8.077	P 27 (28-1)
405	18327.988	8.021	R105 (30-1)
		7.988	P 71 (26-0)
406	18327.764	7.766	P102 (30-1)
407	18327.675	7.681	P 96 (33-2)
		7.674	R145 (29-0)
408	18327.564	7.567	R 31 (28-1)
409	18327.379	7.384	P142 (29-0)
		7.377	R 79 (29-1)
410	18327.253	7.255	P 28 (28-1)
411	18327.135	7.139	R 99 (33-2)
412	18327.024	7.026	R 75 (26-0)
413	18326.869	6.871	P 76 (29-1)
414	18326.725	6.728	R 32 (28-1)
	18326.625		
415	18326.401	6.406	P 29 (28-1)
		6.400	R106 (27-0)
416	18326.251	6.255	R128 (28-0)
417	18325.995	5.996	P 72 (26-0)
		5.937	P122 (31-1)
418	18325.859	5.861	R 33 (28-1)
419	18325.777	5.791	P169 (31-0)
	18325.683	5.719	R125 (31-1)
420	18325.477	5.529	P 30 (28-1)
		5.480	P125 (28-0)
421	18325.339	5.342	P103 (27-0)
422	18325.145	5.147	R 80 (29-1)
423	18325.015	5.018	R 76 (26-0)
		4.968	R106 (30-1)
		4.966	R 34 (28-1)
	18324.849	4.849	P157 (30-0)
424	18324.799		
425	18324.709	4.717	P103 (30-1)
426	18324.631	4.663	P 97 (33-2)
		4.638	P 77 (29-1)
		4.626	R172 (31-0)
		4.625	P 31 (28-1)
	18324.477	4.478	R160 (30-0)
427	18323.977	4.110	R100 (33-2)
		4.043	R 35 (28-1)
		3.976	P 73 (26-0)
	18323.798		
428	18323.695	3.692	P 32 (28-1)
429	18323.471	3.474	R107 (27-0)
		3.435	R146 (29-0)
430	18323.155	3.155	P143 (29-0)
431	18323.095	3.093	R 36 (28-1)
432	18322.982	2.982	R 77 (26-0)
433	18322.890	2.889	R 81 (29-1)

LINE	OBS CM-1	CALC	ASSIGNMENT
434	18322.739	2.732	P 33 (28-1)
435	18322.621	2.618	R129 (28-0)
436	18322.406	2.411	P104 (27-0)
		2.377	P 78 (29-1)
	18322.206	2.206	P123 (31-1)
437	18322.115	2.115	R 37 (28-1)
438	18321.929	1.978	R126 (31-1)
		1.929	P 74 (26-0)
439	18321.844	1.885	R107 (30-1)
		1.845	P126 (28-0)
440	18321.745	1.744	P 34 (28-1)
441	18321.609	1.637	P104 (30-1)
		1.614	P 98 (33-2)
442	18321.111	1.109	R 38 (28-1)
	18321.051	1.049	R101 (33-2)
443	18320.918	0.920	R 78 (26-0)
444	18320.721	0.730	R 1 (25-0)
		0.729	P 35 (28-1)
		0.726	R 2 (25-0)
		0.708	R 0 (25-0)
		0.695	R 3 (25-0)
	18320.615	0.638	R 4 (25-0)
		0.601	R 82 (29-1)
		0.585	P 1 (25-0)
445	18320.518	0.554	R 5 (25-0)
		0.519	R108 (27-0)
		0.488	P170 (31-0)
		0.484	P 2 (25-0)
446	18320.451	0.445	R 6 (25-0)
447	18320.310	0.357	P 3 (25-0)
		0.308	R 7 (25-0)
448	18320.146	0.203	P 4 (25-0)
		0.146	R 8 (25-0)
449	18320.077	0.086	P 79 (29-1)
		0.075	R 39 (28-1)
450	18320.032	0.050	P158 (30-0)
		0.023	P 5 (25-0)
451	18319.958	9.957	R 9 (25-0)
452	18319.854	9.855	P 75 (26-0)
		9.817	P 6 (25-0)
453	18319.743	9.742	R 10 (25-0)
454	18319.683	9.685	P 36 (28-1)
		9.662	R161 (30-0)
455	18319.586	9.584	P 7 (25-0)
456	18319.500	9.500	R 11 (25-0)
457	18319.451	9.451	P105 (27-0)
458	18319.325	9.325	P 8 (25-0)
		9.296	R173 (31-0)
459	18319.233	9.232	R 12 (25-0)
	18319.165	9.165	R147 (29-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
448	18320.146	0.203	P 4 (25-0)
		0.146	R 8 (25-0)
449	18320.077	0.086	P 79 (29-1)
		0.075	R 39 (28-1)
450	18320.032	0.050	P158 (30-0)
		0.023	P 5 (25-0)
451	18319.958	9.957	R 9 (25-0)
452	18319.854	9.855	P 75 (26-0)
		9.817	P 6 (25-0)
453	18319.743	9.742	R 10 (25-0)
454	18319.683	9.685	P 36 (28-1)
		9.662	R161 (30-0)
455	18319.586	9.584	P 7 (25-0)
456	18319.500	9.500	R 11 (25-0)
457	18319.451	9.451	P105 (27-0)
458	18319.325	9.325	P 8 (25-0)
		9.296	R173 (31-0)
459	18319.233	9.232	R 12 (25-0)
	18319.165	9.165	R147 (29-0)
460	18319.035	9.040	P 9 (25-0)
		9.013	R 40 (28-1)
461	18318.941	8.952	R130 (28-0)
		8.936	R 13 (25-0)
		8.894	P144 (29-0)
462	18318.829	8.829	R 79 (26-0)
463	18318.730	8.772	R108 (30-1)
		8.728	P 10 (25-0)
464	18318.617	8.617	R 14 (25-0)
		8.614	P 37 (28-1)
465	18318.527	8.533	P 99 (33-2)
		8.526	P105 (30-1)
466	18318.391	8.390	P 11 (25-0)
467	18318.273	8.285	R 83 (29-1)
		8.270	R 15 (25-0)
468	18318.179	8.204	R127 (31-1)
		8.180	P127 (28-0)
469	18318.027	8.026	P 12 (25-0)
470	18317.901	7.956	R102 (33-2)
		7.924	R 41 (28-1)
		7.897	R 16 (25-0)
471	18317.753	7.766	P 80 (29-1)
		7.754	P 76 (26-0)
472	18317.635	7.635	P 13 (25-0)
473	18317.508	7.536	R109 (27-0)
		7.515	P 38 (28-1)
		7.497	R 17 (25-0)
474	18317.219	7.218	P 14 (25-0)
475	18317.070	7.071	R 18 (25-0)
476	18316.777	6.807	R 42 (28-1)
		6.774	P 15 (25-0)
477	18316.710	6.711	R 80 (26-0)
478	18316.618	6.618	R 19 (25-0)
479	18316.460	6.463	P106 (27-0)
480	18316.389	6.388	P 39 (28-1)
481	18316.304	6.304	P 16 (25-0)
482	18316.140	6.139	R 20 (25-0)
483	18315.947	5.939	R 84 (29-1)
484	18315.808	5.808	P 17 (25-0)
485	18315.629	5.661	R 43 (28-1)
		5.634	R 21 (25-0)
		5.628	R109 (30-1)
		5.624	P 77 (26-0)
486	18315.412	5.421	P100 (33-2)
		5.418	P 81 (29-1)
		5.388	P106 (30-1)
487	18315.279	5.286	P 18 (25-0)
		5.255	R131 (28-0)
		5.234	P 40 (28-1)
		5.219	P159 (30-0)
488	18315.103	5.150	P171 (31-0)
		5.102	R 22 (25-0)
	18314.855	4.863	R148 (29-0)
		4.832	R103 (33-2)
		4.813	R162 (30-0)
489	18314.736	4.737	P 19 (25-0)
490	18314.552	4.602	P145 (29-0)
		4.566	R 41 (28-1)
		4.544	R 23 (25-0)
		4.524	R110 (27-0)
		4.488	R 44 (28-1)
		4.486	P128 (28-0)
	18314.397	4.399	R128 (31-1)
	18314.291		
491	18314.161	4.161	P 20 (25-0)
492	18314.055	4.051	P 41 (28-1)
493	18313.960	3.960	R 24 (25-0)
		3.931	R174 (31-0)
494	18313.560	3.564	R 85 (29-1)
		3.560	P 21 (25-0)
495	18313.458	3.468	P 78 (26-0)
		3.447	P107 (27-0)
496	18313.348	3.349	R 25 (25-0)
	18313.295	3.287	R 45 (28-1)
497	18313.037	3.040	P 82 (29-1)
498	18312.932	2.931	P 22 (25-0)
499	18312.843	2.841	P 42 (28-1)
500	18312.712	2.712	R 26 (25-0)
501	18312.392	2.454	R110 (30-1)
		2.393	R 82 (26-0)
502	18312.276	2.277	P 23 (25-0)
		2.277	P101 (33-2)
		2.218	P107 (30-1)
	18312.160		
503	18312.048	2.059	R 46 (28-1)
		2.048	R 27 (25-0)
	18311.671	1.675	R104 (33-2)
504	18311.599	1.603	P 43 (28-1)
		1.596	P 24 (25-0)
505	18311.483	1.528	R132 (28-0)
		1.483	R111 (27-0)
506	18311.359	1.358	R 28 (25-0)
507	18311.284	1.284	P 79 (26-0)
508	18311.160	1.160	R 86 (29-1)
509	18311.017		
510	18310.888	0.889	P 25 (25-0)
	18310.802	0.802	R 47 (28-1)
511	18310.764	0.762	P129 (28-0)
512	18310.640	0.641	R 29 (25-0)
		0.634	P 83 (29-1)
513	18310.533	0.562	R129 (31-1)
		0.530	R149 (29-0)
		0.402	P108 (27-0)
514	18310.400	0.356	P160 (30-0)
515	18310.343	0.337	P 44 (28-1)
		0.279	P146 (29-0)
516	18310.283	0.193	R 83 (26-0)
517	18310.182	0.155	P 26 (25-0)
		9.931	R163 (30-0)
518	18309.898	9.898	R 30 (25-0)
	18309.773	9.778	P172 (31-0)
519	18309.518	9.517	R 48 (28-1)
520	18309.394	9.395	P 27 (25-0)
	18309.248	9.250	R111 (30-1)
521	18309.129	9.129	R 31 (25-0)
522	18309.072	9.101	P102 (33-2)
		9.073	P 80 (26-0)
		9.043	P 45 (28-1)
		9.018	P108 (30-1)
523	18308.728	8.728	R 87 (29-1)
524	18308.608	8.609	P 28 (25-0)
		8.531	R175 (31-0)
525	18308.412	8.487	R105 (33-2)
		8.414	R112 (27-0)
526	18308.333	8.333	R 32 (25-0)
527	18308.203	8.205	R 49 (28-1)
		8.198	P 84 (29-1)
528	18308.093		
529	18307.965	7.964	R 84 (26-0)
530	18307.792	7.796	P 29 (25-0)
		7.771	R133 (28-0)
		7.722	P 46 (28-1)
531	18307.510	7.510	R 33 (25-0)
532	18307.325	7.328	P109 (27-0)
533	18307.060	*****	ARTIFACT
534	18306.957	7.007	P130 (28-0)
		6.956	P 30 (25-0)
535	18306.836	6.864	R 50 (28-1)
		6.834	P 81 (26-0)
536	18306.662	6.693	R130 (31-1)
		6.661	R 34 (25-0)
	18306.560		
537	18306.373	6.372	P 47 (28-1)
538	18306.265	6.265	R 88 (29-1)
	18306.161	6.165	R150 (29-0)
539	18306.091	6.091	P 31 (25-0)
		6.015	R112 (30-1)
540	18305.921	5.925	P147 (29-0)
		5.893	P103 (33-2)
541	18305.787	5.788	P109 (30-1)
		5.786	R 35 (25-0)
542	18305.710	5.734	P 85 (29-1)
		5.709	R 85 (26-0)
543	18305.494	5.496	R 51 (28-1)
		5.459	P161 (30-0)
544	18305.313	5.315	R113 (27-0)
		5.267	R106 (33-2)
545	18305.198	5.199	P 32 (25-0)
	18305.115		
546	18304.997	5.016	R164 (30-0)
		4.995	P 48 (28-1)
547	18304.885	4.884	R 36 (25-0)
548	18304.568	4.567	P 82 (26-0)
	18304.368		
549	18304.279	4.280	P 33 (25-0)
550	18304.226	4.225	P110 (27-0)
551	18304.100	4.100	R 52 (28-1)
552	18303.958	3.983	R134 (28-0)
		3.956	R 37 (25-0)
553	18303.772	3.774	P 89 (29-1)
554	18303.596	3.590	P 49 (28-1)
555	18303.425	3.426	R 86 (26-0)
556	18303.334	3.335	P 34 (25-0)
557	18303.226	3.240	P 86 (29-1)
		3.223	P131 (28-0)
	18303.090	3.097	R176 (31-0)
558	18303.001	3.001	R 38 (25-0)
CALC	*********	2.792	R131 (31-1)
CALC	*********	2.750	R113 (30-1)
559	18302.676	2.675	R 53 (28-1)
		2.654	P104 (33-2)
	18302.526	2.527	P110 (30-1)
560	18302.364	2.363	P 35 (25-0)
561	18302.275	2.274	P 83 (26-0)
562	18302.179	2.188	R114 (27-0)
		2.157	P 50 (28-1)
563	18302.020	2.020	R 39 (25-0)
		2.014	R107 (33-2)
564	18301.770	1.769	R151 (29-0)
565	18301.540	1.539	P148 (29-0)
566	18301.366	1.365	P 36 (25-0)
567	18301.231	1.254	R 90 (29-1)
		1.223	R 54 (28-1)
568	18301.106	1.115	R 87 (26-0)
		1.094	P111 (27-0)
569	18301.012	1.012	R 40 (25-0)
570	18300.950		
571	18300.703	0.718	P 87 (29-1)
		0.696	P 51 (28-1)
	18300.611		
	18300.529	0.530	P162 (30-0)
572	18300.341	0.341	P 37 (25-0)
573	18300.173	0.166	R135 (28-0)
	18300.069	0.068	R165 (30-0)
574	18299.969	9.978	R 41 (25-0)
		9.952	P 84 (26-0)
575	18299.743	9.743	R 55 (28-1)



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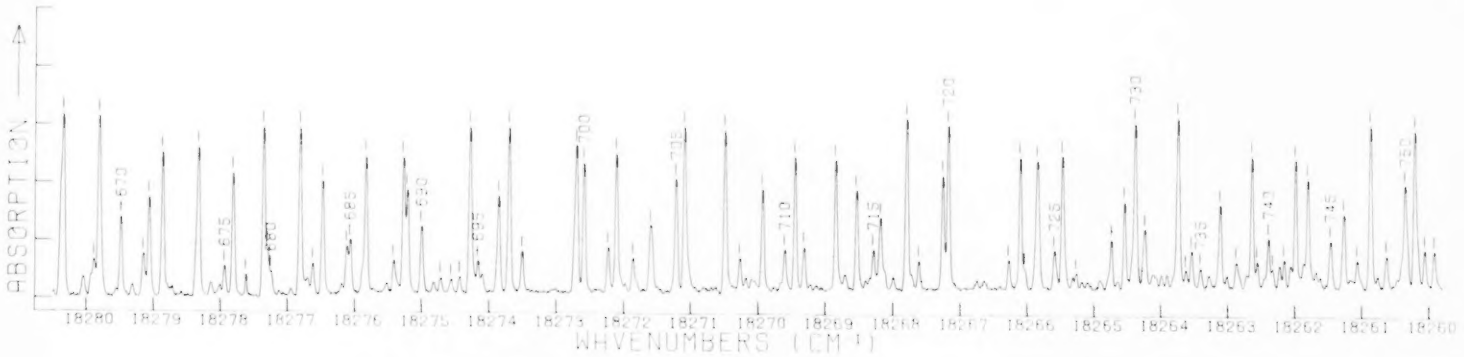
572	18300.341	0.341	P 37 (25-0)
573	18300.173	0.166	R135 (28-0)
	18300.069	0.068	R165 (30-0)
574	18299.969	9.978	R 41 (25-0)
		9.952	P 84 (26-0)
575	18299.743	9.743	R 55 (28-1)
576	18299.407	9.454	R114 (30-1)
		9.409	P132 (28-0)
		9.362	P105 (33-2)
577	18299.290	9.290	P 38 (25-0)
	18299.204	9.236	P111 (30-1)
		9.207	P 52 (28-1)
578	18299.033	9.032	R115 (27-0)
579	18298.918	8.917	R 42 (25-0)
		8.859	R132 (31-1)
580	18298.775	8.776	R 88 (26-0)
581	18298.708	8.730	R108 (33-2)
		8.704	R 91 (29-1)
	18298.530		
582	18298.372		
583	18298.214	8.234	R 56 (28-1)
		8.213	P 39 (25-0)
		8.166	P 88 (29-1)
584	18297.933	7.934	P112 (27-0)
585	18297.831	7.830	R 43 (25-0)
586	18297.692	7.690	P 53 (28-1)
587	18297.602	7.628	R177 (31-0)
		7.603	P 85 (26-0)
	18297.455		
588	18297.340	7.340	R152 (29-0)
589	18297.110	7.122	P149 (29-0)
		7.109	P 40 (25-0)
590	18297.033	*****	ARTIFACT
591	18296.920	*****	ARTIFACT
592	18296.714	6.716	R 44 (25-0)
		6.698	R 57 (28-1)
593	18296.409	6.410	R 89 (26-0)
594	18296.318	6.318	R136 (28-0)
595	18296.136	6.145	P 54 (28-1)
		6.127	R115 (30-1)
		6.125	R 92 (29-1)
		6.079	P106 (33-2)
596	18295.977	5.979	P 41 (25-0)
		5.915	P112 (30-1)
597	18295.843	5.847	R116 (27-0)
598	18295.575	5.585	P 89 (29-1)
		5.576	R 45 (25-0)
		5.568	P163 (30-0)
		5.565	P133 (28-0)
	18295.408	5.413	R109 (33-2)
599	18295.226	5.227	P 86 (26-0)
600	18295.134	5.134	R 58 (28-1)
		5.086	R166 (30-0)
	18294.892	4.894	R133 (31-1)
601	18294.821	4.822	P 42 (25-0)
602	18294.745	4.746	P113 (27-0)
603	18294.574	4.572	P 55 (28-1)
604	18294.410	4.409	R 46 (25-0)
	18294.318		
605	18294.190		
606	18294.015	4.016	R 90 (26-0)
607	18293.945	*****	ARTIFACT
608	18293.638	3.639	P 43 (25-0)
609	18293.537	3.541	R 59 (28-1)
		3.517	R 93 (29-1)
	18293.449		
	18293.320		
610	18293.215	3.216	R 47 (25-0)
611	18292.973	2.975	P 90 (29-1)
		2.971	P 56 (28-1)
612	18292.822	2.881	R153 (29-0)
		2.823	P 87 (26-0)
		2.770	R116 (30-1)
		2.744	P107 (33-2)
613	18292.632	2.674	P150 (29-0)
		2.633	R117 (27-0)
	18292.567	2.563	P113 (30-1)
614	18292.430	2.440	R137 (28-0)
		2.429	P 44 (25-0)
	18292.125	2.123	R178 (31-0)
615	18291.995	1.996	R 48 (25-0)
616	18291.923	1.921	R 60 (28-1)
617	18291.689	1.691	P134 (28-0)
618	18291.593	1.594	R 91 (26-0)
619	18291.526	1.528	P114 (27-0)
620	18291.344	1.343	P 57 (28-1)
621	18291.193	1.193	P 45 (25-0)
622	18290.880	0.898	R134 (31-1)
		0.880	R 94 (29-1)
623	18290.748	0.749	R 49 (25-0)
	18290.571	0.572	P164 (30-0)
	18290.494		
624	18290.391	0.391	P 88 (26-0)
		0.336	P 91 (29-1)
625	18290.272	0.272	R 61 (28-1)
CALC	**********	0.072	R167 (30-0)
626	18289.930	9.930	P 46 (25-0)
627	18289.687	9.686	P 58 (28-1)
628	18289.475	9.476	R 50 (25-0)
629	18289.386	9.390	R118 (27-0)
		9.383	R117 (30-1)
		9.377	P108 (33-2)
630	18289.146	9.181	P114 (30-1)
		9.145	R 92 (26-0)
631	18288.639	8.641	P 47 (25-0)
		8.595	R 62 (28-1)
632	18288.531	8.532	R138 (28-0)
CALC	**********	8.389	R154 (29-0)
633	18288.280	8.282	P115 (27-0)
634	18288.177	8.213	R 95 (29-1)
		8.194	P151 (29-0)
		8.176	R 51 (25-0)
635	18288.002	8.001	P 59 (28-1)
636	18287.932	7.932	P 89 (26-0)
637	18287.788	7.786	P135 (28-0)
	18287.665	7.668	P 92 (29-1)
638	18287.446	*****	ARTIFACT
639	18287.322	7.325	P 48 (25-0)
640	18286.851	6.891	R 63 (28-1)
		6.869	R135 (31-1)
		6.850	R 52 (25-0)
641	18286.667	6.668	R 93 (26-0)
642	18286.290	6.288	P 60 (28-1)
643	18286.116	6.118	R119 (27-0)
644	18285.980	5.982	P 49 (25-0)
		5.978	P109 (33-2)
		5.965	R118 (30-1)
	18285.766	5.768	P115 (30-1)
	18285.629		
645	18285.497	5.544	P165 (30-0)
		5.517	R 96 (29-1)
		5.496	R 53 (25-0)
		5.445	P 90 (26-0)
646	18285.450		
	18285.270		
647	18285.158	5.158	R 64 (28-1)
648	18285.003	5.023	R168 (30-0)
		5.007	P116 (27-0)
		4.970	P 93 (29-1)
649	18284.611	4.613	P 50 (25-0)
		4.593	R139 (28-0)
650	18284.560	4.548	P 61 (28-1)
651	18284.117	4.163	R 94 (26-0)
		4.117	R 54 (25-0)
652	18283.856	3.866	R155 (29-0)
		3.852	P136 (28-0)
653	18283.680	3.682	P152 (29-0)
654	18283.398	3.397	R 65 (28-1)
655	18283.216	3.218	P 51 (25-0)
656	18282.930	2.930	P 91 (26-0)
657	18282.802	2.817	R120 (27-0)
		2.808	R136 (31-1)
		2.791	R 97 (29-1)
		2.779	P 62 (28-1)
658	18282.709	2.711	R 55 (25-0)
	18282.521	2.547	P110 (33-2)
		2.516	R119 (30-1)
659	18282.330	2.325	P116 (30-1)
	18282.241	2.244	P 94 (29-1)
660	18281.948		
661	18281.795	1.795	P 52 (25-0)
662	18281.701	1.703	P117 (27-0)
663	18281.626	1.630	R 95 (26-0)
		1.608	R 66 (28-1)
664	18281.278	1.278	R 56 (25-0)
665	18280.985	0.982	P 63 (28-1)
666	18280.627	0.624	R140 (28-0)
	18280.482	0.483	P166 (30-0)
667	18280.348	0.388	P 92 (26-0)
		0.347	P 53 (25-0)
	18280.040	0.036	R 98 (29-1)
668	18279.890	9.942	R169 (30-0)
		9.888	P137 (28-0)
669	18279.814	9.818	R 57 (25-0)
		9.790	R 67 (28-1)



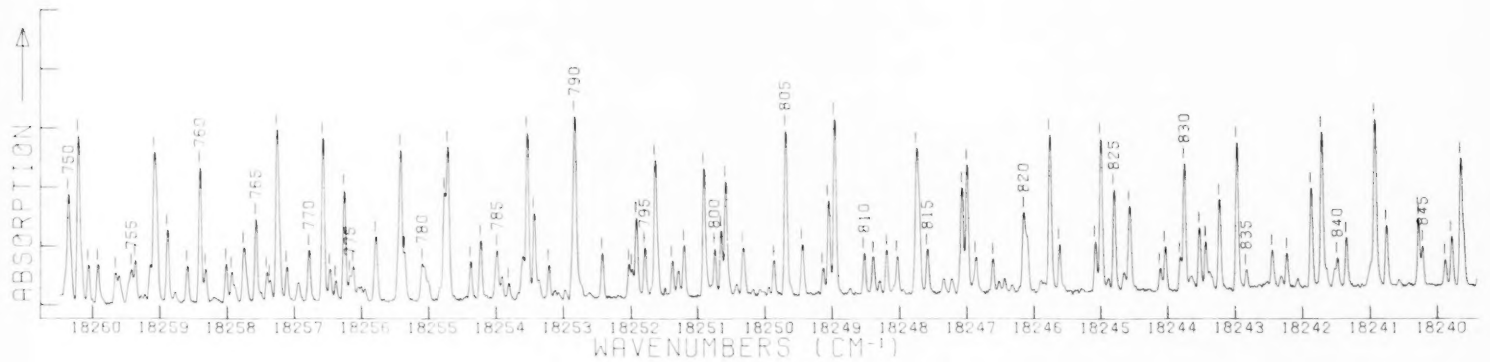
LINE	OBS CM-1	CALC	ASSIGNMENT
667	18280.348	0.388	P 92 (26-0)
		0.347	P 53 (25-0)
	18280.040	0.036	R 98 (29-1)
668	18279.890	9.942	R169 (30-0)
		9.886	P137 (28-0)
669	18279.814	9.818	R 57 (25-0)
		9.790	R 67 (28-1)
670	18279.485	9.488	P 95 (29-1)
		9.487	R121 (27-0)
	18279.310	9.310	R156 (29-0)
671	18279.153	9.157	P 64 (28-1)
		9.139	P153 (29-0)
672	18279.069	9.084	P111 (33-2)
		9.069	R 96 (26-0)
		9.036	R120 (30-1)
673	18278.871	8.871	P 54 (25-0)
		8.851	P117 (30-1)
	18278.715	8.714	R137 (31-1)
674	18278.332	8.370	P118 (27-0)
		8.332	R 58 (25-0)
	18278.145		
	18278.017		
675	18277.945	7.945	R 68 (28-1)
676	18277.819	7.818	P 93 (26-0)
677	18277.627		
678	18277.368	7.369	P 55 (25-0)
679	18277.311	7.304	P 65 (28-1)
680	18277.258	7.252	R 99 (29-1)
	18276.950		
681	18276.819	6.819	R 59 (25-0)
	18276.703	6.703	P 96 (29-1)
682	18276.627	6.625	R141 (28-0)
683	18276.481	6.481	R 97 (26-0)
	18276.201		
684	18276.124	6.127	R122 (27-0)
685	18276.073	6.071	R 69 (28-1)
686	18275.840	5.893	P138 (28-0)
		5.841	P 56 (25-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
	18275.525	5.589	P112 (33-2)
		5.526	R121 (30-1)
687	18275.421	5.423	P 66 (28-1)
		5.388	P167 (30-0)
		5.347	P118 (30-1)
688	18275.278	5.279	R 60 (25-0)
689	18275.221	5.220	P 94 (26-0)
690	18275.006	5.009	P119 (27-0)
	18274.825	4.827	R170 (30-0)
691	18274.726	4.723	R157 (29-0)
692	18274.567	4.564	P154 (29-0)
693	18274.438	4.438	R100 (29-1)
694	18274.285	4.286	P 57 (25-0)
695	18274.170	4.169	R 70 (28-1)
	18274.109		
696	18273.866	3.868	P 97 (29-1)
		3.865	R 98 (26-0)
697	18273.711	3.713	R 61 (25-0)
698	18273.515	3.514	P 67 (28-1)
699	18272.705	2.739	R123 (27-0)
		2.704	P 58 (25-0)
700	18272.595	2.595	R142 (28-0)
		2.595	P 95 (26-0)
701	18272.240	2.239	R 71 (28-1)
702	18272.119	2.120	R 62 (25-0)
		2.061	P113 (33-2)
	18271.985	1.984	R122 (30-1)
703	18271.866	1.868	P139 (28-0)
		1.812	P119 (30-1)
704	18271.605	1.618	P120 (27-0)
		1.595	R101 (29-1)
		1.576	P 68 (28-1)
705	18271.221	1.220	R 99 (26-0)
706	18271.095	1.095	P 59 (25-0)
		1.044	P 98 (29-1)
707	18270.499	0.500	R 63 (25-0)

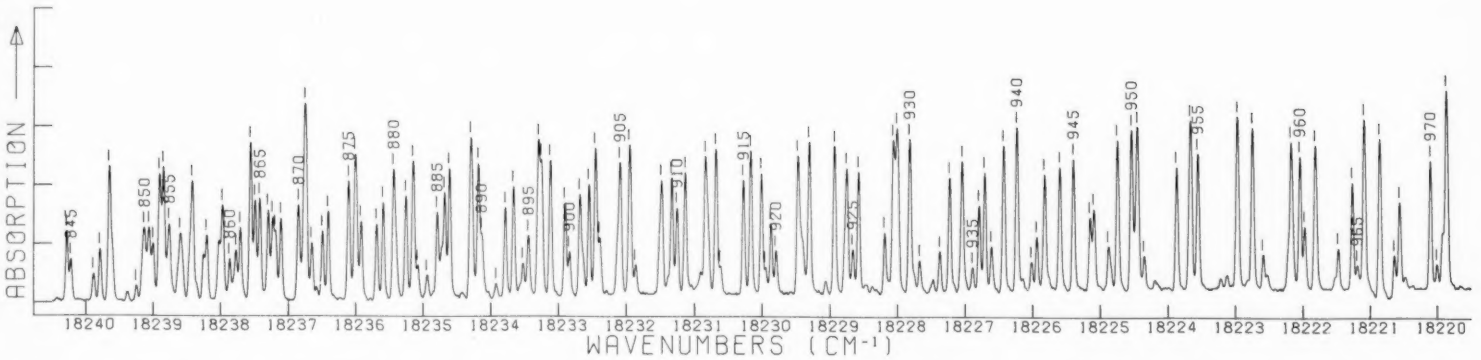
LINE	OBS CM-1	CALC	ASSIGNMENT
708	18270.281	0.281	R 72 (28-1)
		0.260	P168 (30-0)
	18270.188		
	18270.063	0.104	R158 (29-0)
709	18269.944	9.958	P155 (29-0)
		9.942	P 96 (26-0)
710	18269.612	9.678	R171 (30-0)
		9.611	P 69 (28-1)
		4.827	R170 (30-0)
711	18269.459	9.460	P 60 (25-0)
712	18269.321	9.322	R124 (27-0)
713	18268.853	8.853	R 64 (25-0)
	18268.717	8.722	R102 (29-1)
714	18268.545	8.548	R100 (26-0)
		8.534	R143 (28-0)
		8.502	P114 (33-2)
	18268.410	8.412	R123 (30-1)
715	18268.298	8.294	R 73 (28-1)
		8.247	P120 (30-1)
716	18268.194	8.198	P121 (27-0)
		8.171	P 99 (29-1)
	18267.999		
717	18267.799	7.812	P140 (28-0)
		7.798	P 61 (25-0)
718	18267.618	7.617	P 70 (28-1)
719	18267.261	7.261	P 97 (26-0)
720	18267.179	7.180	R 65 (25-0)
	18266.749		
	18266.638		
721	18266.280	6.279	R 74 (28-1)
722	18266.108	6.110	P 62 (25-0)
723	18266.042		
724	18265.853	5.875	R125 (27-0)
		5.848	R101 (26-0)
		5.820	R103 (29-1)
725	18265.597	5.595	P 71 (28-1)
726	18265.479	5.480	R 66 (25-0)
		5.453	R159 (29-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
727	18265.266	5.320	P156 (29-0)
		5.269	P100 (29-1)
	18265.186		
	18265.101	5.100	P169 (30-0)
	18264.914	4.911	P115 (33-2)
728	18264.750	4.810	R124 (30-1)
		4.750	P122 (27-0)
	18264.652	4.651	P121 (30-1)
729	18264.553	4.552	P 98 (26-0)
		4.496	R172 (30-0)
730	18264.395	4.443	R144 (28-0)
		4.441	R 1 (27-1)
		4.434	R 2 (27-1)
		4.421	R 0 (27-1)
		4.400	R 3 (27-1)
		4.394	P 63 (25-0)
		4.339	R 4 (27-1)
731	18264.248	4.300	P 1 (27-1)
		4.251	R 5 (27-1)
		4.236	R 75 (28-1)
		4.198	P 2 (27-1)
	18264.125	4.135	R 6 (27-1)
		4.069	P 3 (27-1)
	18263.993	3.993	R 7 (27-1)
	18263.910	3.914	P 4 (27-1)
732	18263.750	3.823	R 8 (27-1)
		3.753	R 67 (25-0)
		3.731	P 5 (27-1)
		3.727	P141 (28-0)
733	18263.630	3.696	R 9 (27-1)
734	18263.547	3.565	P 72 (28-1)
		3.521	P 6 (27-1)
735	18263.408	3.402	R 10 (27-1)
	18263.282	3.284	P 7 (27-1)
736	18263.121	3.151	R 11 (27-1)
		3.120	R102 (26-0)
	18263.021	3.019	P 8 (27-1)

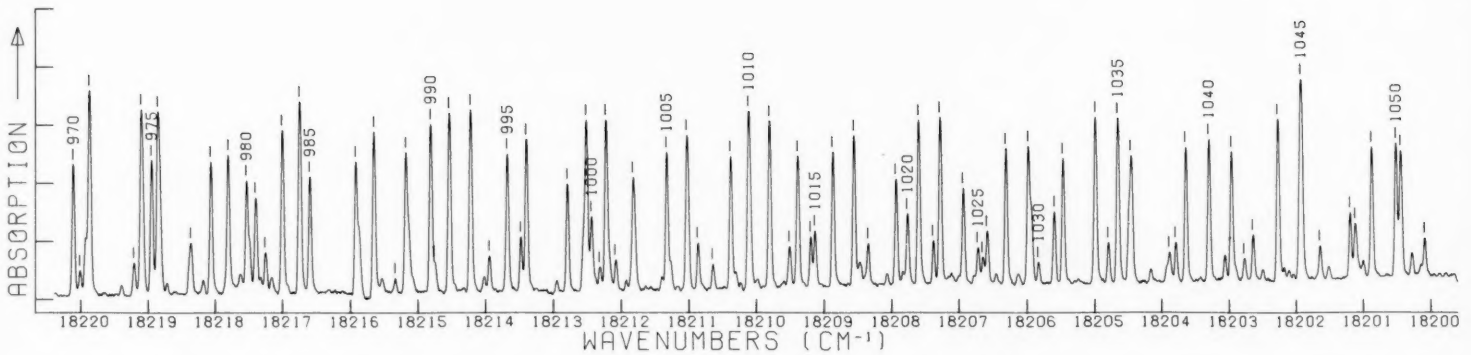
LINE	OBS CM-1	CALC	ASSIGNMENT
737	18262.880	2.888	R104 (29-1)
		2.873	R 12 (27-1)
	18262.727	2.726	P 9 (27-1)
738	18262.652	2.653	P 64 (25-0)
739	18262.573	2.567	R 13 (27-1)
740	18262.402	2.410	P 10 (27-1)
		2.399	R126 (27-0)
741	18262.340	2.337	P101 (29-1)
	18262.232	2.235	R 14 (27-1)
742	18262.166	2.165	R 76 (28-1)
	18262.068	2.064	P 11 (27-1)
743	18261.998	1.999	R 68 (25-0)
	18261.876	1.875	R 15 (27-1)
744	18261.816	1.815	P 99 (26-0)
	18261.693	1.691	P 12 (27-1)
	18261.632		
745	18261.475	1.488	R 16 (27-1)
		1.467	P 73 (28-1)
746	18261.277	1.291	P 13 (27-1)
		1.272	P123 (27-0)
	18261.146	1.176	R125 (30-1)
747	18261.075	1.074	R 17 (27-1)
		1.024	P122 (30-1)
748	18260.881	0.884	P 65 (25-0)
		0.864	P 14 (27-1)
	18260.771	0.769	R160 (29-0)
749	18260.640	0.650	P157 (29-0)
		0.633	R 18 (27-1)
750	18260.364	0.410	P 15 (27-1)
		0.365	R103 (26-0)
		0.322	R145 (28-0)
751	18260.218	0.219	R 69 (25-0)
		0.219	R 69 (25-0)
		0.165	R 19 (27-1)
752	18260.066	0.065	R 77 (28-1)
753	18259.927	9.929	P 16 (27-1)
		9.927	R105 (29-1)
		9.905	P170 (30-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
750	18260.364	0.410	P 15 (27-1)
		0.365	R103 (26-0)
		0.322	R145 (28-0)
751	18260.218	0.219	R 69 (25-0)
		0.165	R 19 (27-1)
752	18260.066	0.065	R 77 (28-1)
753	18259.927	9.929	P 16 (27-1)
		9.927	R105 (29-1)
		9.905	P170 (30-0)
754	18259.664	9.669	R 20 (27-1)
	18259.612	9.611	P142 (28-0)
755	18259.426	9.421	P 17 (27-1)
756	18259.368	9.375	P102 (29-1)
		9.360	P 74 (28-1)
	18259.277	9.280	R173 (30-0)
	18259.220		
	18259.145	9.147	R 21 (27-1)
757	18259.085	9.089	P 66 (25-0)
		9.051	P100 (26-0)
758	18258.892	8.894	R127 (27-0)
		8.885	P 18 (27-1)
	18258.782		
759	18258.600	8.597	R 22 (27-1)
760	18258.410	8.411	R 70 (25-0)
761	18258.326	8.322	P 19 (27-1)
762	18258.024	8.020	R 23 (27-1)
763	18257.939	7.936	R 78 (28-1)
764	18257.759	7.765	P124 (27-0)
		7.732	P 20 (27-1)
765	18257.581	7.581	R104 (26-0)
	18257.509	7.511	R126 (30-1)
766	18257.416	7.415	R 24 (27-1)
767	18257.370	7.367	P123 (30-1)
768	18257.264	7.266	P 67 (25-0)
		7.225	P 75 (28-1)
769	18257.118	7.115	P 21 (27-1)
	18256.942	6.936	R106 (29-1)
770	18256.784	6.784	R 25 (27-1)
771	18256.576	6.577	R 71 (25-0)
772	18256.470	6.471	P 22 (27-1)
773	18256.385	6.384	P103 (29-1)
774	18256.259	6.259	P101 (26-0)
775	18256.176	6.169	R146 (28-0)
776	18256.129	6.125	R 26 (27-1)
	18256.053	6.054	R161 (29-0)
	18256.008		
	18255.951	5.949	P158 (29-0)
777	18255.793	5.800	P 23 (27-1)
		5.780	R 79 (28-1)
778	18255.419	5.464	P143 (28-0)
		5.440	R 27 (27-1)
		5.418	P 68 (25-0)
779	18255.362	5.359	R128 (27-0)
780	18255.104	5.101	P 24 (27-1)
	18255.067	5.062	P 76 (28-1)
	18255.009		
	18254.828		
781	18254.768	4.769	R105 (26-0)
782	18254.719	4.727	R 28 (27-1)
		4.716	R 72 (25-0)
		4.678	P171 (30-0)
783	18254.377	4.375	P 25 (27-1)
784	18254.229	4.229	P125 (27-0)
785	18253.991	4.030	R174 (30-0)
		3.986	R 29 (27-1)
	18253.916	3.915	R107 (29-1)
786	18253.815	3.815	R127 (30-1)
	18253.607	3.678	P124 (30-1)
		3.623	P 26 (27-1)
		3.595	R 80 (28-1)
787	18253.542	3.542	P 69 (25-0)
788	18253.439	3.439	P102 (26-0)
	18253.366	3.364	P104 (29-1)
789	18253.221	3.219	R 30 (27-1)
	18253.134		
	18253.075		
	18252.974		
790	18252.831	2.871	P 77 (28-1)
		2.842	P 27 (27-1)
		2.828	R 73 (25-0)
791	18252.427	2.424	R 31 (27-1)
792	18252.036	2.035	P 28 (27-1)
793	18251.992	1.986	R147 (28-0)
794	18251.926	1.929	R106 (26-0)
795	18251.795	1.796	R129 (27-0)
796	18251.638	1.639	P 70 (25-0)
		1.602	R 32 (27-1)
797	18251.384	1.381	R 81 (28-1)
	18251.291	1.306	R162 (29-0)
		1.288	P144 (28-0)
798	18251.206	1.215	P159 (29-0)
		1.201	P 29 (27-1)
799	18250.912	0.913	R 74 (25-0)
		0.865	R108 (29-1)
800	18250.755	0.753	R 33 (27-1)
801	18250.660	0.664	P126 (27-0)
		0.651	P 78 (28-1)
802	18250.592	0.590	P103 (26-0)
	18250.425		
803	18250.333	0.339	P 30 (27-1)
		0.314	P105 (29-1)
	18250.188		
	18250.089	0.088	R128 (30-1)
	18250.040		
804	18249.958	9.959	P125 (30-1)
805	18249.879	9.877	R 34 (27-1)
806	18249.709	9.710	P 71 (25-0)
	18249.455	9.450	P 31 (27-1)
		9.416	P172 (30-0)
807	18249.143	9.139	R 82 (28-1)
808	18249.061	9.061	R107 (26-0)
809	18248.971	8.973	R 35 (27-1)
		8.972	R 75 (25-0)
	18248.746	8.746	R175 (30-0)
810	18248.535	8.534	P 32 (27-1)
811	18248.405	8.403	P 79 (28-1)
	18248.305		
812	18248.204	8.203	R130 (27-0)
813	18248.044	8.042	R 36 (27-1)
814	18247.753	7.745	R109 (29-1)
		7.773	R148 (28-0)
		7.754	P 72 (25-0)
		7.714	P104 (26-0)
815	18247.592	7.591	P 33 (27-1)
	18247.348		
	18247.229	7.235	P106 (29-1)
816	18247.079	7.084	R 37 (27-1)
		7.080	P145 (28-0)
		7.070	P127 (27-0)
817	18247.003	7.003	R 76 (25-0)
818	18246.871	6.869	R 83 (28-1)
819	18246.621	6.620	P 34 (27-1)
	18246.528	6.527	R163 (29-0)
	18246.448	6.450	P160 (29-0)
	18246.330	6.330	R129 (30-1)
820	18246.160	6.209	P126 (30-1)
		6.164	R108 (26-0)
		6.127	P 80 (28-1)
		6.099	R 38 (27-1)
	18245.901		
	18245.846		
821	18245.770	5.771	P 73 (25-0)
822	18245.624	5.622	P 35 (27-1)
823	18245.089	5.086	R 39 (27-1)
824	18245.007	5.007	R 77 (25-0)
	18244.895		
825	18244.810	4.811	P105 (26-0)
	18244.667	4.675	R110 (29-1)
826	18244.582	4.597	P 36 (27-1)
		4.580	R131 (27-0)
		4.570	R 84 (28-1)
827	18244.127	4.126	P107 (29-1)
		4.122	P173 (30-0)
828	18244.049	4.046	R 40 (27-1)
829	18243.825	3.822	P 81 (28-1)
830	18243.762	3.762	P 74 (25-0)
	18243.625		
831	18243.542	3.545	P 37 (27-1)
		3.528	R149 (28-0)
832	18243.448	3.447	P128 (27-0)
	18243.385		
833	18243.240	3.240	R109 (26-0)
834	18242.984	2.985	R 78 (25-0)
		2.979	R 41 (27-1)
835	18242.844	2.842	P146 (28-0)
836	18242.465	2.466	P 38 (27-1)
		2.429	P127 (30-1)
	18242.328		
837	18242.244	2.243	R 85 (28-1)
	18242.081		
838	18241.881	1.884	R 42 (27-1)
		1.879	P106 (26-0)
839	18241.725	1.725	P 75 (25-0)
		1.715	R164 (29-0)
	18241.659	1.652	P161 (29-0)
840	18241.490	1.535	R111 (29-1)
		1.489	P 82 (28-1)
841	18241.359	1.359	P 39 (27-1)
842	18240.934	0.987	P108 (29-1)
		0.936	R 79 (25-0)
		0.928	R132 (27-0)
843	18240.763	0.762	R 43 (27-1)
	18240.570		
844	18240.288	0.288	R110 (26-0)
845	18240.226	0.225	P 40 (27-1)
846	18239.890	9.887	R 86 (28-1)
847	18239.796	9.794	P129 (27-0)
848	18239.661	9.662	P 76 (25-0)
		9.613	R 44 (27-1)



LINE	OBS CM-1	CALC	ASSIGNMENT
844	18240.288	0.288	R110 (26-0)
845	18240.226	0.225	P 40 (27-1)
846	18239.890	9.887	R 86 (28-1)
847	18239.796	9.794	P129 (27-0)
848	18239.661	9.662	P 76 (25-0)
		9.613	R 44 (27-1)
	18239.390		
849	18239.256	9.253	R150 (28-0)
850	18239.141	9.176	R 1 (24-0)
		9.173	R 2 (24-0)
		9.153	R 0 (24-0)
		9.144	R 3 (24-0)
		9.128	P 83 (28-1)
851	18239.072	9.089	R 4 (24-0)
		9.063	P 41 (27-1)
852	18239.011	9.029	P 1 (24-0)
		9.009	R 5 (24-0)
853	18238.916	8.929	P 2 (24-0)
		8.919	P107 (26-0)
		8.902	R 6 (24-0)
854	18238.859	8.859	R 80 (25-0)
855	18238.774	8.803	P 3 (24-0)
		8.794	P174 (30-0)
		8.770	R 7 (24-0)
856	18238.609	8.650	P 4 (24-0)
		8.617	P128 (30-1)
		8.612	R 8 (24-0)
		8.574	P147 (28-0)
857	18238.434	8.472	P 5 (24-0)
		8.436	R 45 (27-1)
		8.428	R 9 (24-0)
		8.366	R112 (29-1)
	18238.263	8.268	P 6 (24-0)
858	18238.218	8.218	R 10 (24-0)
	18238.034	8.039	P 7 (24-0)
859	18237.984	7.982	R 11 (24-0)
860	18237.877	7.875	P 42 (27-1)
861	18237.784	7.819	P109 (29-1)
		7.783	P 8 (24-0)
862	18237.721	7.721	R 12 (24-0)
863	18237.572	7.571	P 77 (25-0)
864	18237.503	7.503	R 87 (28-1)
		7.502	P 9 (24-0)
865	18237.434	7.433	R 13 (24-0)
866	18237.307	7.307	R111 (26-0)
867	18237.239	7.247	R133 (27-0)
		7.232	R 46 (27-1)
868	18237.200	7.194	P 10 (24-0)
869	18237.119	7.120	R 14 (24-0)
870	18236.859	6.870	R165 (29-0)
		6.861	P 11 (24-0)
		6.823	P162 (29-0)
871	18236.761	6.780	R 15 (24-0)
		6.756	R 81 (25-0)
		6.738	P 84 (28-1)
872	18236.661	6.659	P 43 (27-1)
	18236.584		
873	18236.502	6.502	P 12 (24-0)
874	18236.416	6.415	R 16 (24-0)
875	18236.115	6.117	P 13 (24-0)
		6.112	P130 (27-0)
876	18236.017	6.024	R 17 (24-0)
		6.000	R 47 (27-1)
877	18235.931	5.931	P108 (26-0)
878	18235.705	5.706	P 14 (24-0)
879	18235.607	5.607	R 18 (24-0)
880	18235.452	5.454	P 78 (25-0)
		5.416	P 44 (27-1)
881	18235.270	5.269	P 15 (24-0)
882	18235.164	5.167	R113 (29-1)
		5.164	R 19 (24-0)
883	18235.094	5.090	R 88 (28-1)
884	18234.954	4.947	R151 (28-0)
885	18234.806	4.807	P 16 (24-0)
		4.774	P129 (30-1)
886	18234.696	4.742	R 48 (27-1)
		4.696	R 20 (24-0)
887	18234.625	4.625	R 82 (25-0)
		4.621	P110 (29-1)
	18234.436		
888	18234.312	4.320	P 85 (28-1)
		4.318	P 17 (24-0)
		4.298	R112 (26-0)
		4.275	P148 (28-0)
889	18234.202	4.201	R 21 (24-0)
890	18234.153	4.145	P 45 (27-1)
891	18233.937		
892	18233.803	3.804	P 18 (24-0)
893	18233.679	3.681	R 22 (24-0)
894	18233.537	3.536	R134 (27-0)
895	18233.457	3.456	R 49 (27-1)
		3.432	P175 (30-0)
896	18233.309	3.310	P 79 (25-0)
897	18233.270	3.264	P 19 (24-0)
898	18233.135	3.134	R 23 (24-0)
899	18232.916	2.915	P109 (26-0)
900	18232.850	2.847	P 46 (27-1)
901	18232.696	2.698	P 20 (24-0)
		2.649	R 89 (28-1)
902	18232.562	2.562	R 24 (24-0)
903	18232.468	2.468	R 83 (25-0)
904	18232.405	2.401	P131 (27-0)
905	18232.107	2.142	R 50 (27-1)
		2.106	P 21 (24-0)
906	18231.964	1.993	R166 (29-0)
		1.964	R 25 (24-0)
		1.961	P163 (29-0)
		1.937	R114 (29-1)
907	18231.876	1.873	P 86 (28-1)
908	18231.490	1.522	P 47 (27-1)
		1.488	P 22 (24-0)
909	18231.339	1.394	P111 (29-1)
		1.339	R 26 (24-0)
910	18231.262	1.261	R113 (26-0)
911	18231.139	1.139	P 80 (25-0)
	18231.040		
	18230.909	0.900	P130 (30-1)
912	18230.842	0.844	P 23 (24-0)
		0.801	R 51 (27-1)
		0.689	R 27 (24-0)
913	18230.689	0.610	R152 (28-0)
914	18230.624	0.610	R152 (28-0)
915	18230.283	0.283	R 84 (25-0)
916	18230.174	0.178	R 90 (28-1)
		0.174	P 24 (24-0)
		0.169	P 48 (27-1)
917	18230.014	0.013	R 28 (24-0)
918	18229.953	9.945	P149 (28-0)
919	18229.871	9.871	P110 (26-0)
920	18229.798	9.795	R135 (27-0)
921	18229.477	9.479	P 25 (24-0)
		9.433	R 52 (27-1)
		9.398	P 87 (28-1)
922	18229.311	9.311	R 29 (24-0)
	18229.066		
923	18228.941	8.941	P 81 (25-0)
924	18228.760	8.769	P 49 (27-1)
		8.757	P 26 (24-0)
925	18228.667	8.678	R115 (29-1)
		8.661	P132 (27-0)
926	18228.583	8.583	R 30 (24-0)
	18228.469		
	18228.372		
927	18228.196	8.196	R114 (26-0)
		8.137	P112 (29-1)
928	18228.068	8.072	R 85 (25-0)
929	18228.014	8.037	R 53 (27-1)
		8.036	P176 (30-0)
		8.010	P 27 (24-0)
930	18227.830	7.830	R 31 (24-0)
931	18227.683	7.680	R 91 (28-1)
	18227.478		
932	18227.383	7.382	P 50 (27-1)
933	18227.236	7.237	P 28 (24-0)
934	18227.051	7.084	R167 (29-0)
		7.067	P164 (29-0)
		7.050	R 32 (24-0)
		6.996	P131 (30-1)
935	18226.896	6.894	P 88 (28-1)
936	18226.799	6.798	P111 (26-0)
937	18226.717	6.716	P 82 (25-0)
938	18226.616	6.614	R 54 (27-1)
939	18226.436	6.437	P 29 (24-0)
940	18226.244	6.244	R 33 (24-0)
		6.241	R153 (28-0)
	18226.149		
941	18226.027	6.025	R136 (27-0)
942	18225.950	5.947	P 51 (27-1)
943	18225.835	5.833	R 86 (25-0)
944	18225.611	5.612	P 30 (24-0)
		5.585	P150 (28-0)
945	18225.412	5.412	R 34 (24-0)
		5.390	R116 (29-1)
946	18225.161	5.163	R 55 (27-1)
		5.152	R 92 (28-1)
947	18225.104	5.102	R115 (26-0)
948	18224.890	4.891	P133 (27-0)
		4.850	P113 (29-1)
949	18224.761	4.761	P 31 (24-0)
950	18224.554	4.555	R 35 (24-0)
951	18224.468	4.485	P 52 (27-1)
		4.464	P 83 (25-0)
952	18224.365	4.362	P 89 (28-1)
	18224.208		
	18224.174		
953	18223.884	3.884	P 32 (24-0)
954	18223.678	3.698	P112 (26-0)
		3.685	R 56 (27-1)
		3.671	R 36 (24-0)
955	18223.568	3.567	R 87 (25-0)
	18223.227		
	18223.135		
CALC	*********	3.060	P132 (30-1)
956	18222.984	2.996	P 53 (27-1)
		2.981	P 33 (24-0)
957	18222.761	2.761	R 37 (24-0)
958	18222.600	2.607	P177 (30-0)
		2.596	R 93 (28-1)
	18222.536		
959	18222.185	2.226	R137 (27-0)
		2.185	P 84 (25-0)
		2.179	R 57 (27-1)
		2.142	R168 (29-0)
		2.141	P165 (29-0)
960	18222.053	2.071	R117 (29-1)
		2.052	P 34 (24-0)
961	18221.980	1.980	R116 (26-0)
962	18221.825	1.842	R154 (28-0)
		1.825	R 38 (24-0)
		1.801	P 90 (28-1)
963	18221.481	1.533	P114 (29-1)
		1.479	P 54 (27-1)
964	18221.274	1.274	R 88 (25-0)
965	18221.198	1.194	P151 (28-0)
966	18221.097	1.097	P 35 (24-0)
		1.092	P134 (27-0)
967	18220.864	0.864	R 39 (24-0)
968	18220.645	0.646	R 58 (27-1)
969	18220.571	0.569	P113 (26-0)
	18220.484		
970	18220.116	0.116	P 36 (24-0)
971	18220.016	0.012	R 94 (28-1)
	18219.934	9.935	P 55 (27-1)
972	18219.877	9.879	P 85 (25-0)
		9.876	R 40 (24-0)



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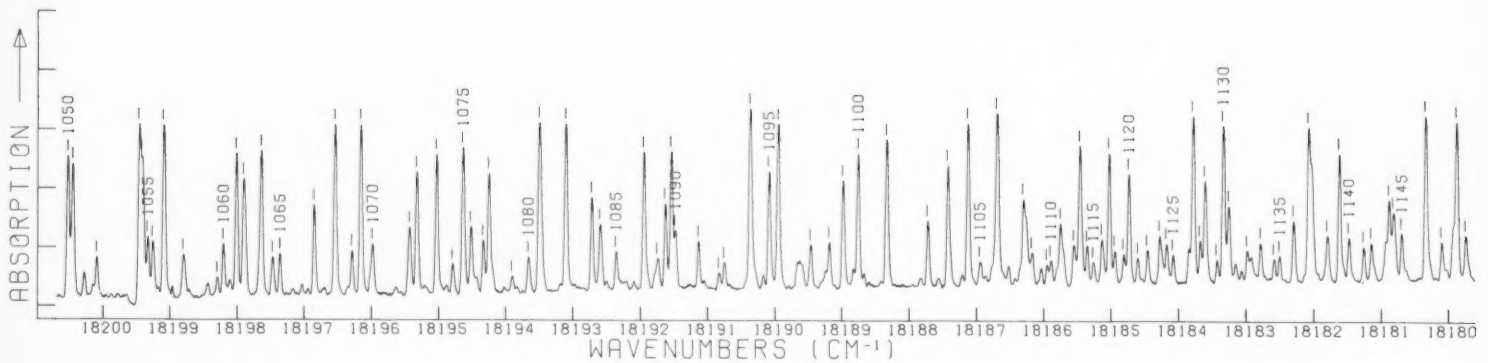
971	18220.016	0.012	R 94 (28-1)
	18219.934	9.935	P 55 (27-1)
972	18219.877	9.879	P 85 (25-0)
		9.876	R 40 (24-0)
	18219.396		
973	18219.215	9.212	P 91 (28-1)
974	18219.104	9.110	P 37 (24-0)
		9.093	P133 (30-1)
		9.085	R 59 (27-1)
975	18218.955	8.954	R 89 (25-0)
976	18218.859	8.862	R 41 (24-0)
		8.830	R117 (26-0)
	18218.721	8.722	R118 (29-1)
977	18218.370	8.396	R138 (27-0)
		8.363	P 56 (27-1)
	18218.186	8.186	P115 (29-1)
978	18218.077	8.077	P 38 (24-0)
979	18217.823	7.823	R 42 (24-0)
	18217.635		
980	18217.547	7.546	P 86 (25-0)
		7.497	R 60 (27-1)
981	18217.411	7.413	P114 (26-0)
		7.412	R155 (28-0)
		7.398	R 95 (28-1)
	18217.334		
982	18217.266	7.263	P135 (27-0)
	18217.175	7.183	P166 (29-0)
		7.168	R169 (29-0)
		7.143	P178 (30-0)
983	18217.018	7.018	P 39 (24-0)
984	18216.759	6.772	P152 (28-0)
		6.764	P 57 (27-1)
		6.757	R 43 (24-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
985	18216.606	6.607	R 90 (25-0)
		6.594	P 92 (28-1)
986	18215.933	5.933	P 40 (24-0)
		5.881	R 61 (27-1)
987	18215.662	5.665	R 44 (24-0)
		5.651	R118 (26-0)
	18215.539		
988	18215.344	5.343	R119 (29-1)
989	18215.186	5.186	P 87 (25-0)
		5.137	P 58 (27-1)
		5.095	P134 (30-1)
990	18214.822	4.823	P 41 (24-0)
		4.810	P116 (29-1)
991	18214.761	4.756	R 96 (28-1)
992	18214.547	4.547	R 45 (24-0)
		4.537	R139 (27-0)
993	18214.233	4.238	R 62 (27-1)
		4.233	R 91 (25-0)
		4.228	P115 (26-0)
	18214.029		
994	18213.950	3.947	P 93 (28-1)
995	18213.687	3.686	P 42 (24-0)
996	18213.485	3.483	P 59 (27-1)
997	18213.405	3.405	P136 (27-0)
		3.403	R 46 (24-0)
	18212.955	2.951	R156 (28-0)
998	18212.800	2.799	P 88 (25-0)
999	18212.524	2.567	R 63 (27-1)
		2.523	P 43 (24-0)
1000	18212.446	2.444	R119 (26-0)
1001	18212.323	2.319	P153 (28-0)
1002	18212.234	2.233	R 47 (24-0)
		2.193	P167 (29-0)
		2.161	R170 (29-0)

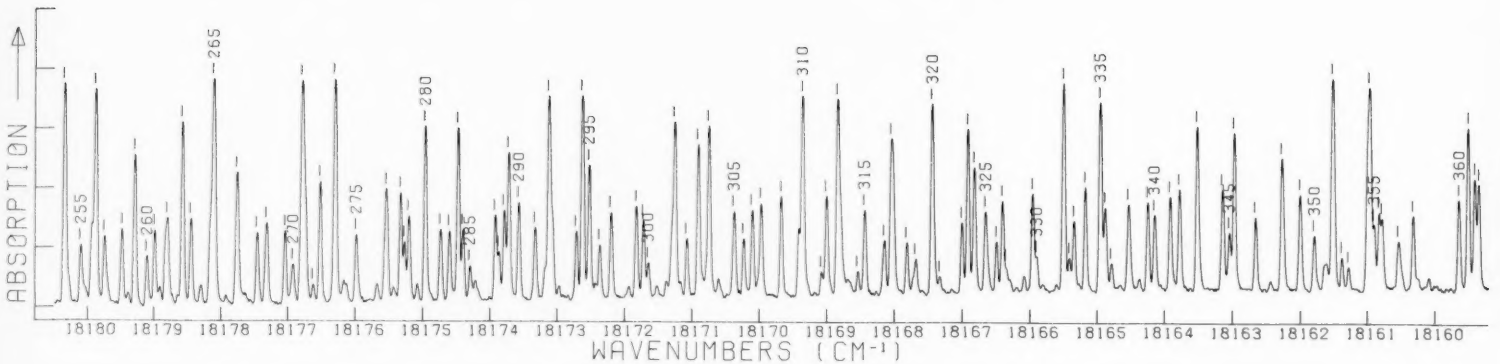
LINE	OBS CM-1	CALC	ASSIGNMENT
1003	18212.090	2.085	R 97 (28-1)
	18211.936	1.934	R120 (29-1)
1004	18211.829	1.831	R 92 (25-0)
		1.802	P 60 (27-1)
	18211.645	1.646	P179 (30-0)
	18211.404	1.404	P117 (29-1)
1005	18211.334	1.334	P 44 (24-0)
		1.272	P 94 (28-1)
1006	18211.034	1.066	P135 (30-1)
		1.037	R 48 (24-0)
		1.015	P116 (26-0)
1007	18210.871	0.869	R 64 (27-1)
1008	18210.650	0.649	R140 (27-0)
1009	18210.385	0.385	P 89 (25-0)
	18210.306		
1010	18210.117	0.120	P 45 (24-0)
		0.093	P 61 (27-1)
	18209.990		
1011	18209.817	9.815	R 49 (24-0)
1012	18209.520	9.517	P137 (27-0)
1013	18209.402	9.403	R 93 (25-0)
		9.385	R 98 (28-1)
1014	18209.209	9.209	R120 (26-0)
1015	18209.147	9.143	R 65 (27-1)
1016	18208.880	8.879	R 46 (24-0)
1017	18208.568	8.568	P 95 (28-1)
		8.567	R 50 (24-0)
	18208.473	8.494	R121 (29-1)
		8.458	R157 (28-0)
1018	18208.358	8.356	P 62 (27-1)
	18208.079		

LINE	OBS CM-1	CALC	ASSIGNMENT
1019	18207.946	7.967	P118 (29-1)
		7.944	P 90 (25-0)
	18207.840	7.835	P154 (28-0)
1020	18207.775	7.773	P117 (26-0)
1021	18207.613	7.612	P 47 (24-0)
1022	18207.392	7.389	R 66 (27-1)
1023	18207.294	7.293	R 51 (24-0)
	18207.121	7.170	P168 (29-0)
		7.121	R171 (29-0)
1024	18206.948	7.005	P136 (30-1)
		6.947	R 94 (25-0)
1025	18206.732	6.730	R141 (27-0)
1026	18206.661	6.656	R 99 (28-1)
1027	18206.594	6.592	P 63 (27-1)
	18206.465		
1028	18206.319	6.319	P 48 (24-0)
	18206.142		
1029	18205.993	5.992	R 52 (24-0)
		5.945	R121 (26-0)
1030	18205.841	5.836	P 96 (28-1)
1031	18205.608	5.608	R 67 (27-1)
		5.600	P138 (27-0)
1032	18205.477	5.475	P 91 (25-0)
1033	18205.001	5.025	R122 (29-1)
		5.000	P 49 (24-0)
1034	18204.802	4.801	P 64 (27-1)
1035	18204.667	4.666	R 53 (24-0)
1036	18204.468	4.504	P118 (26-0)
		4.501	P119 (29-1)
		4.464	R 95 (25-0)
	18204.177		

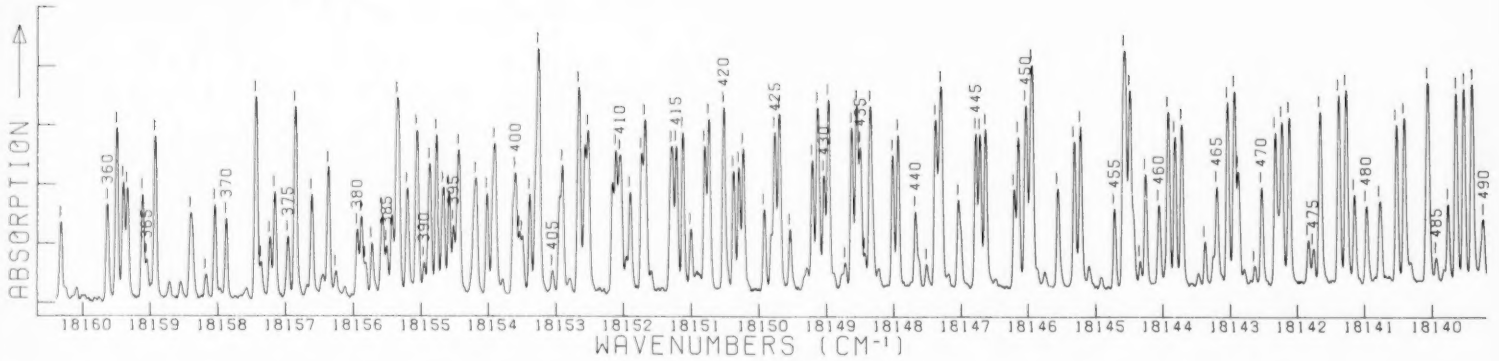
LINE	OBS CM-1	CALC	ASSIGNMENT
1037	18203.896	3.935	R158 (28-0)
		3.899	R100 (28-1)
1038	18203.802	3.799	R 68 (27-1)
1039	18203.656	3.655	P 50 (24-0)
1040	18203.315	3.321	P155 (28-0)
		3.313	R 54 (24-0)
	18203.075	3.075	P 97 (28-1)
1041	18202.982	2.981	P 65 (27-1)
		2.980	P 92 (25-0)
		2.913	P137 (30-1)
1042	18202.784	2.782	R142 (27-0)
1043	18202.655	2.652	R122 (26-0)
	18202.509		
1044	18202.284	2.284	P 51 (24-0)
	18202.186		
	18202.115	2.115	P169 (29-0)
	18202.052	2.048	R172 (29-0)
1045	18201.942	1.963	R 69 (27-1)
		1.953	R 96 (25-0)
		1.934	R 55 (24-0)
1046	18201.657	1.653	P139 (27-0)
	18201.524	1.526	R123 (29-1)
1047	18201.206	1.206	P119 (26-0)
1048	18201.130	1.135	P 66 (27-1)
		1.113	R101 (28-1)
	18201.011	1.005	P120 (29-1)
1049	18200.888	0.887	P 52 (24-0)
1050	18200.531	0.529	R 56 (24-0)
1051	18200.459	0.457	P 93 (25-0)
	18200.285	0.285	P 98 (28-1)
	18200.156		
1052	18200.101	0.099	R 70 (27-1)



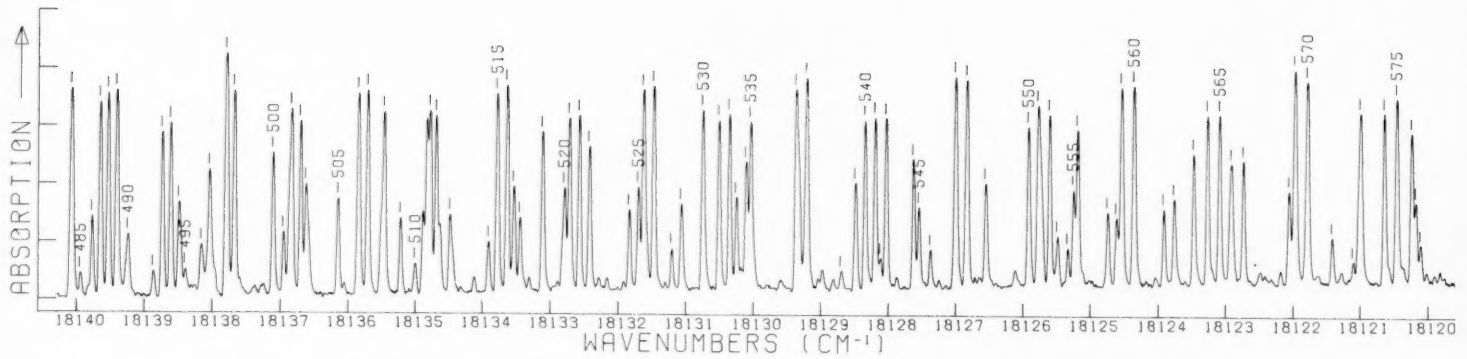
LINE	OBS CM-1	CALC	ASSIGNMENT
1050	18200.531	0.529	R 56 (24-0)
1051	18200.459	0.457	P 93 (25-0)
	18200.285	0.285	P 98 (28-1)
	18200.156		
1052	18200.101	0.099	R 70 (27-1)
1053	18199.464	9.464	P 53 (24-0)
1054	18199.422	9.415	R 97 (25-0)
1055	18199.336	9.380	R159 (28-0)
		9.332	R123 (26-0)
1056	18199.262	9.260	P 67 (27-1)
1057	18199.100	9.098	R 57 (24-0)
1058	18198.802	8.804	R143 (27-0)
		8.790	P138 (30-1)
		8.775	P156 (28-0)
	18198.440		
1059	18198.300	8.297	R102 (28-1)
1060	18198.209	8.207	R 71 (27-1)
	18198.110		
1061	18198.014	8.014	P 54 (24-0)
		7.996	R124 (29-1)
1062	18197.903	7.907	P 94 (25-0)
		7.879	P120 (26-0)
1063	18197.643	7.676	P140 (27-0)
		7.641	R 58 (24-0)
1064	18197.472	7.479	P121 (29-1)
		7.466	P 99 (28-1)
1065	18197.362	7.359	P 68 (27-1)
	18197.167		
	18197.029	7.027	P170 (29-0)
	18196.945	6.943	R173 (29-0)
1066	18196.851	6.850	R 98 (25-0)
	18196.694		
1067	18196.540	6.539	P 55 (24-0)
1068	18196.290	6.287	R 72 (27-1)
1069	18196.159	6.158	R 59 (24-0)
1070	18195.987	5.982	R124 (26-0)
	18195.635		
1071	18195.437	5.453	R103 (28-1)
		5.429	P 69 (27-1)
1072	18195.332	5.330	P 95 (25-0)
	18195.225		
1073	18195.039	5.037	P 56 (24-0)
	18194.887		
1074	18194.798	4.796	R144 (27-0)
		4.794	R160 (28-0)
1075	18194.647	4.648	R 60 (24-0)
		4.636	P139 (30-1)
		4.618	P100 (28-1)
1076	18194.528	4.525	P121 (26-0)
	18194.447	4.436	R125 (29-1)
1077	18194.342	4.340	R 73 (27-1)
1078	18194.258	4.258	R 99 (25-0)
		4.199	P157 (28-0)
1079	18193.915	3.922	P122 (29-1)
	18193.844		
1080	18193.672	3.670	P141 (27-0)
1081	18193.509	3.509	P 57 (24-0)
		3.472	P 70 (27-1)
1082	18193.113	3.112	R 61 (24-0)
1083	18192.728	2.726	P 96 (25-0)
1084	18192.602	2.604	R125 (26-0)
		2.580	R104 (28-1)
	18192.509		
1085	18192.368	2.365	R 74 (27-1)
	18192.222		
	18192.105		
1086	18191.956	1.956	P 58 (24-0)
1087	18191.749	1.805	R174 (29-0)
		1.742	P101 (28-1)
1088	18191.639	1.638	R100 (25-0)
1089	18191.552	1.550	R 62 (24-0)
1090	18191.490	1.487	P 71 (27-1)
1091	18191.144	1.142	P122 (26-0)
	18191.063		
1092	18190.838	0.846	R126 (29-1)
1093	18190.760	0.758	R145 (27-0)
1094	18190.374	0.450	P140 (30-1)
		0.376	P 59 (24-0)
		0.362	R 75 (27-1)
		0.336	P123 (29-1)
	18190.182	0.176	R161 (28-0)
1095	18190.096	0.094	P 97 (25-0)
1096	18189.963	9.962	R 63 (24-0)
	18189.640	9.676	R105 (28-1)
		9.634	P142 (27-0)
	18189.607	9.591	P158 (28-0)
1097	18189.477	9.475	P 72 (27-1)
1098	18189.200	9.197	R126 (26-0)
1099	18188.992	8.991	R101 (25-0)
1100	18188.770	8.837	P102 (28-1)
		8.770	P 60 (24-0)
	18188.684		
1101	18188.347	8.347	R 64 (24-0)
		8.332	R 76 (27-1)
	18187.838		
1102	18187.733	7.730	P123 (26-0)
	18187.574		
1103	18187.437	7.436	P 98 (25-0)
		7.435	P 73 (27-1)
	18187.226	7.225	R127 (29-1)
1104	18187.139	7.137	P 61 (24-0)
1105	18186.956	6.972	R 1 (26-1)
		6.967	R 2 (26-1)
		6.951	R 0 (26-1)
		6.935	R 3 (26-1)
	18186.874	6.876	R 4 (26-1)
		6.829	P 1 (26-1)
1106	18186.707	6.791	R 5 (26-1)
		6.747	R106 (28-1)
		6.728	P 2 (26-1)
		6.720	P124 (29-1)
		6.707	R 65 (24-0)
		6.690	R146 (27-0)
		6.679	R 6 (26-1)
		6.634	R175 (29-0)
	18186.537	6.600	P 3 (26-1)
		6.540	R 7 (26-1)
	18186.443	6.446	P 4 (26-1)
1107	18186.314	6.375	R 8 (26-1)
		6.316	R102 (25-0)
		6.274	R 77 (27-1)
		6.265	P 5 (26-1)
1108	18186.186	6.233	P141 (30-1)
		6.183	R 9 (26-1)
	18186.052	6.058	P 6 (26-1)
1109	18185.965	5.965	R 10 (26-1)
1110	18185.905	5.903	P103 (28-1)
1111	18185.764	5.824	P 7 (26-1)
		5.762	R127 (26-0)
		5.720	R 11 (26-1)
1112	18185.567	5.569	P143 (27-0)
		5.563	P 8 (26-1)
		5.527	R162 (28-0)
1113	18185.480	5.479	P 62 (24-0)
		5.448	R 12 (26-1)
1114	18185.370	5.367	P 74 (27-1)
1115	18185.278	5.276	P 9 (26-1)
1116	18185.148	5.150	R 13 (26-1)
1117	18185.041	5.040	R 66 (24-0)
1118	18184.959	4.962	P 10 (26-1)
		4.952	P159 (28-0)
1119	18184.825	4.825	R 14 (26-1)
1120	18184.751	4.750	P 99 (25-0)
1121	18184.617	4.621	P 11 (26-1)
1122	18184.472	4.473	R 15 (26-1)
1123	18184.290	4.290	P124 (26-0)
		4.254	P 12 (26-1)
1124	18184.191	4.187	R 78 (27-1)
1125	18184.094	4.095	R 16 (26-1)
	18183.858	3.860	P 13 (26-1)
1126	18183.794	3.794	P 63 (24-0)
		3.787	R107 (28-1)
1127	18183.689	3.690	R 17 (26-1)
1128	18183.615	3.614	R103 (25-0)
		3.574	R128 (29-1)
1129	18183.439	3.440	P 14 (26-1)
1130	18183.347	3.346	R 67 (24-0)
1131	18183.266	3.272	P 75 (27-1)
		3.258	R 18 (26-1)
	18183.161		
	18183.074	3.073	P125 (29-1)
1132	18182.991	2.992	P 15 (26-1)
	18182.935	2.940	P104 (28-1)
1133	18182.798	2.800	R 19 (26-1)
1134	18182.595	2.592	R147 (27-0)
1135	18182.513	2.519	P 16 (26-1)
1136	18182.305	2.315	R 20 (26-1)
		2.298	R128 (26-0)
1137	18182.081	2.083	P 64 (24-0)
		2.074	R 79 (27-1)
		2.036	P100 (25-0)
		2.018	P 17 (26-1)
		1.984	P142 (30-1)
1138	18181.803	1.804	R 21 (26-1)
1139	18181.627	1.627	R 68 (24-0)
1140	18181.483	1.491	P 18 (26-1)
		1.473	P144 (27-0)
		1.430	R176 (29-0)
1141	18181.263	1.266	R 22 (26-1)
1142	18181.151	1.148	P 76 (27-1)
1143	18180.886	0.938	P 19 (26-1)
		0.885	R104 (25-0)
		0.847	R163 (28-0)
1144	18180.821	0.822	P125 (26-0)
		0.798	R108 (28-1)
1145	18180.699	0.701	R 23 (26-1)
1146	18180.347	0.357	P 20 (26-1)
		0.346	P 65 (24-0)
		0.282	P160 (28-0)
1147	18180.107	0.109	R 24 (26-1)
	18179.936	9.948	P105 (28-1)
		9.932	R 80 (27-1)
1148	18179.882	9.893	R129 (29-1)
		9.881	R 69 (24-0)
1149	18179.749	9.750	P 21 (26-1)



LINE	OBS CM-1	CALC	ASSIGNMENT
254	18180.350	0.357	P 20 (26-1)
		0.346	P 65 (24-0)
		0.282	P160 (28-0)
255	18180.108	0.109	R 24 (26-1)
256	18179.883	9.968	P105 (28-1)
		9.932	R 80 (27-1)
		9.893	R129 (29-1)
		9.881	R 69 (24-0)
257	18179.749	9.750	P 21 (26-1)
258	18179.490	9.491	R 25 (26-1)
	18179.401	9.396	P126 (29-1)
259	18179.299	9.296	P101 (25-0)
260	18179.116	9.117	P 22 (26-1)
261	18179.000	8.998	P 77 (27-1)
	18178.927		
262	18178.813	8.846	R 26 (26-1)
		8.805	R129 (26-0)
263	18178.585	8.583	P 66 (24-0)
264	18178.459	8.464	R148 (27-0)
		8.457	P 23 (26-1)
	18178.316		
265	18178.118	8.174	R 27 (26-1)
		8.128	R105 (25-0)
		8.109	R 70 (24-0)
	18177.946		
266	18177.770	7.779	R109 (28-1)
		7.770	P 24 (26-1)
		7.762	R 81 (27-1)
		7.704	P143 (30-1)
267	18177.473	7.476	R 28 (26-1)
268	18177.334	7.348	P145 (27-0)
		7.325	P126 (26-0)
269	18177.054	7.056	P 25 (26-1)
270	18176.935	6.928	P106 (28-1)
271	18176.796	6.819	P 78 (27-1)
		6.793	P 67 (24-0)
		6.751	R 29 (26-1)
272	18176.635		
273	18176.530	6.528	P102 (25-0)
274	18176.312	6.316	P 26 (26-1)
		6.310	R 71 (24-0)
	18176.185	6.192	R177 (29-0)
		6.181	R130 (29-1)
	18176.151	6.135	R164 (28-0)
275	18175.997	5.999	R 30 (26-1)
	18175.693	5.689	P127 (29-1)
276	18175.556	5.581	P161 (28-0)
		5.565	R 82 (27-1)
		5.549	P 27 (26-1)
	18175.448		
277	18175.345	5.344	R106 (25-0)
278	18175.287	5.284	R130 (26-0)
279	18175.221	5.221	R 31 (26-1)
	18175.099		
280	18174.979	4.977	P 68 (24-0)
281	18174.750	4.755	P 28 (26-1)
		4.732	R110 (28-1)
282	18174.614	4.613	P 79 (27-1)
283	18174.487	4.485	R 72 (24-0)
284	18174.415	4.416	R 32 (26-1)
285	18174.311	4.306	R149 (27-0)
	18174.235		
286	18173.934	3.935	P 29 (26-1)
287	18173.883	3.878	P107 (28-1)
288	18173.801	3.799	P127 (26-0)
289	18173.735	3.732	P103 (25-0)
290	18173.584	3.584	R 33 (26-1)
291	18173.341	3.392	P144 (30-1)
		3.339	R 83 (27-1)
292	18173.136	3.193	P146 (27-0)
		3.135	P 69 (24-0)
		3.088	P 30 (26-1)
	18172.991		
293	18172.725	2.725	R 34 (26-1)
294	18172.635	2.634	R 73 (24-0)
295	18172.533	2.532	R107 (25-0)
	18172.441	2.439	R131 (29-1)
296	18172.379	2.378	P 80 (27-1)
297	18172.212	2.214	P 31 (26-1)
	18171.955	1.952	P128 (25-1)
298	18171.839	1.840	R 35 (26-1)
299	18171.733	1.734	R131 (26-0)
300	18171.660	1.655	R111 (28-1)
	18171.538		
	18171.396	1.392	R165 (28-0)
301	18171.268	1.314	P 32 (26-1)
		1.267	P 70 (24-0)
	18171.187		
302	18171.089	1.086	R 84 (27-1)
303	18170.916	0.928	R 36 (26-1)
		0.922	R178 (29-0)
		0.910	P104 (25-0)
		0.849	P162 (28-0)
304	18170.757	0.799	P108 (28-1)
		0.756	R 74 (24-0)
	18170.623		
305	18170.386	0.387	P 33 (26-1)
306	18170.246	0.245	P128 (26-0)
307	18170.118	0.118	R150 (27-0)
		0.116	P 81 (27-1)
308	18169.989	9.989	R 37 (26-1)
309	18169.693	9.692	R108 (25-0)
	18169.433	9.433	P 34 (26-1)
310	18169.374	9.372	P 71 (24-0)
311	18169.094	9.088	P145 (30-1)
312	18169.019	9.023	R 38 (26-1)
		9.008	P147 (27-0)
313	18168.853	8.852	R 75 (24-0)
		8.805	R 85 (27-1)
	18168.675	8.666	R132 (29-1)
314	18168.552	8.549	R112 (28-1)
315	18168.451	8.452	P 35 (26-1)
316	18168.158	8.184	P129 (29-1)
		8.155	R132 (26-0)
317	18168.053	8.060	P105 (25-0)
		8.031	R 39 (26-1)
318	18167.828	7.827	R 82 (27-1)
319	18167.693	7.692	P109 (28-1)
320	18167.450	7.451	P 72 (24-0)
		7.445	P 36 (26-1)
321	18167.339		
322	18167.011	7.011	R 40 (26-1)
323	18166.922	6.922	R 76 (24-0)
324	18166.826	6.825	R109 (25-0)
325	18166.660	6.662	P129 (26-0)
		6.616	R166 (28-0)
326	18166.498	6.496	R 86 (27-1)
327	18166.410	6.411	P 37 (26-1)
328	18166.361		
	18166.089	6.085	P163 (28-0)
329	18165.963	5.965	R 41 (26-1)
330	18165.908	5.899	R151 (27-0)
	18165.614	5.619	R179 (29-0)
331	18165.506	5.509	P 83 (27-1)
		5.504	P 73 (24-0)
332	18165.419	5.414	R113 (28-1)
333	18165.350	5.350	P 38 (26-1)
334	18165.184	5.182	P106 (25-0)
335	18164.966	4.965	R 77 (24-0)
336	18164.890	4.893	R 42 (26-1)
		4.863	R133 (29-1)
337	18164.799	4.794	P148 (27-0)
	18164.674	4.673	P146 (30-1)
338	18164.548	4.555	R110 (28-1)
		4.547	R133 (26-0)
	18164.391	4.386	P130 (29-1)
339	18164.262	4.263	P 39 (26-1)
340	18164.160	4.159	R 87 (27-1)
341	18163.931	3.931	R110 (25-0)
342	18163.792	3.793	R 43 (26-1)
343	18163.530	3.531	P 74 (24-0)
344	18163.153	3.164	P 84 (27-1)
		3.148	P 40 (26-1)
345	18163.054	3.051	P130 (26-0)
346	18162.983	2.982	R 78 (24-0)
347	18162.666	2.667	R 44 (26-1)
	18162.449		
348	18162.276	2.277	P107 (25-0)
		2.250	R114 (28-1)
349	18162.007	2.007	P 41 (26-1)
350	18161.798	1.810	R167 (28-0)
		1.794	R 88 (27-1)
	18161.647	1.651	R152 (27-0)
351	18161.526	1.531	P 75 (24-0)
		1.513	R 45 (26-1)
352	18161.389	1.389	P111 (28-1)
353	18161.289	1.290	P164 (28-0)
354	18160.977	1.029	R134 (29-1)
		1.008	R111 (25-0)
		0.972	R 79 (24-0)
355	18160.913	0.910	R134 (26-0)
356	18160.837	0.839	P 42 (26-1)
357	18160.795	0.790	P 85 (27-1)
358	18160.550	0.558	P131 (29-1)
		0.549	P149 (27-0)
359	18160.332	0.333	R 46 (26-1)
	18160.269		
	18160.100		
360	18159.645	9.645	P 43 (26-1)
361	18159.505	9.504	P 76 (24-0)
362	18159.407	9.411	P131 (26-0)
		9.400	R 89 (27-1)
363	18159.347	9.345	P108 (25-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
359	18160.332	0.333	R 46 (26-1)
	18160.269		
	18160.100		
360	18159.645	9.645	P 43 (26-1)
361	18159.505	9.504	P 76 (24-0)
362	18159.407	9.411	P131 (26-0)
		9.400	R 89 (27-1)
363	18159.347	9.345	P108 (25-0)
364	18159.125	9.126	R 47 (26-1)
365	18159.063	9.057	R115 (28-1)
366	18158.937	8.936	R 80 (24-0)
	18158.730		
	18158.566		
367	18158.414	8.423	P 44 (26-1)
		8.389	P 86 (27-1)
368	18158.193	8.194	P112 (28-1)
369	18158.059	8.059	R112 (25-0)
370	18157.891	7.892	R 48 (26-1)
	18157.594		
371	18157.452	7.452	P 77 (24-0)
372	18157.377	7.372	R153 (27-0)
373	18157.245	7.245	R135 (26-0)
374	18157.174	7.175	P 45 (26-1)
		7.164	R135 (29-1)
375	18156.981	6.979	R 90 (27-1)
		6.971	R168 (28-0)
376	18156.873	6.873	R 81 (24-0)
	18156.703	6.699	P132 (29-1)
377	18156.632	6.632	R 49 (26-1)
	18156.473	6.464	P165 (28-0)
378	18156.386	6.385	P109 (25-0)
379	18156.278	6.274	P150 (27-0)
	18156.149		
380	18155.960	5.960	P 87 (27-1)
381	18155.899	5.900	P 46 (26-1)
382	18155.841	5.834	R116 (28-1)
383	18155.742	5.742	P132 (26-0)
384	18155.585	5.604	R 1 (23-0)
		5.602	R 2 (23-0)
		5.580	R 0 (23-0)
		5.575	R 3 (23-0)
385	18155.523	5.523	R 4 (23-0)
386	18155.445	5.456	P 1 (23-0)
		5.445	R 5 (23-0)
387	18155.364	5.373	P 78 (24-0)
		5.356	P 2 (23-0)
		5.344	R 50 (26-1)
		5.342	R 6 (23-0)
388	18155.217	5.231	P 3 (23-0)
		5.214	R 7 (23-0)
389	18155.074	5.081	R113 (25-0)
		5.080	P 4 (23-0)
		5.060	R 8 (23-0)
390	18154.970	4.970	P113 (28-1)
391	18154.885	4.906	P 5 (23-0)
		4.881	R 9 (23-0)
392	18154.784	4.784	R 82 (24-0)
393	18154.682	4.702	P 6 (23-0)
		4.676	R 10 (23-0)
394	18154.598	4.598	P 47 (26-1)
395	18154.533	4.530	R 91 (27-1)
396	18154.453	4.475	P 7 (23-0)
		4.446	R 11 (23-0)
397	18154.197	4.223	P 8 (23-0)
		4.191	R 12 (23-0)
398	18154.030	4.030	R 51 (26-1)
399	18153.913	3.945	P 9 (23-0)
		3.910	R 13 (23-0)
	18153.799		
400	18153.607	3.642	P 10 (23-0)
		3.603	R 14 (23-0)
401	18153.550	3.550	R136 (26-0)
402	18153.509	3.503	P 88 (27-1)
403	18153.399	3.398	P110 (25-0)
404	18153.270	3.314	P 11 (23-0)
		3.272	R 15 (23-0)
		3.270	P 48 (26-1)
		3.269	R136 (29-1)
		3.267	P 79 (24-0)
405	18153.064	3.063	R154 (27-0)
406	18152.916	2.960	P 12 (23-0)
		2.915	R 16 (23-0)
	18152.810	2.810	P133 (29-1)
407	18152.672	2.689	R 52 (26-1)
		2.669	R 83 (24-0)
	18152.579	2.582	R117 (28-1)
		2.580	P 13 (23-0)
408	18152.534	2.532	R 17 (23-0)
	18152.175	2.176	P 14 (23-0)
409	18152.126	2.124	R 18 (23-0)
		2.101	R169 (28-0)
410	18152.062	2.076	R114 (25-0)
		2.053	R 92 (27-1)
		2.044	P133 (26-0)
	18151.975	1.969	P151 (27-0)
411	18151.913	1.914	P 49 (26-1)
412	18151.743	1.746	P 15 (23-0)
413	18151.693	1.717	P114 (28-1)
		1.691	R 19 (23-0)
	18151.606	1.606	P166 (28-0)
414	18151.299	1.320	R 53 (26-1)
		1.290	P 16 (23-0)
415	18151.233	1.232	R 20 (23-0)
416	18151.136	1.136	P 80 (24-0)
417	18151.017	1.018	P 89 (27-1)
418	18150.809	0.809	P 17 (23-0)
419	18150.748	0.748	R 21 (23-0)
420	18150.527	0.532	P 50 (26-1)
		0.527	R 84 (24-0)
421	18150.383	0.383	P111 (25-0)
422	18150.302	0.303	P 18 (23-0)
423	18150.239	0.239	R 22 (23-0)
424	18149.927	9.925	R 54 (26-1)
425	18149.771	9.827	R137 (26-0)
		9.771	P 19 (23-0)
426	18149.703	9.704	R 23 (23-0)
427	18149.548	9.547	R 93 (27-1)
	18149.302	9.343	R137 (29-1)
		9.300	R118 (28-1)
428	18149.215	9.214	P 20 (23-0)
429	18149.136	9.143	R 24 (23-0)
		9.123	P 51 (26-1)
430	18149.044	9.043	R115 (25-0)
431	18148.978	8.977	P 81 (24-0)
	18148.895	8.890	P134 (29-1)
432	18148.728	8.723	R155 (27-0)
433	18148.632	8.632	P 21 (23-0)
434	18148.557	8.557	R 25 (23-0)
435	18148.506	8.504	P 90 (27-1)
		8.503	R 55 (26-1)
436	18148.437	8.435	P115 (28-1)
437	18148.357	8.358	R 85 (24-0)
		8.318	P134 (26-0)
	18148.234		
438	18148.024	8.024	P 22 (23-0)
439	18147.946	7.946	R 26 (23-0)
440	18147.687	7.687	P 52 (26-1)
		7.634	P152 (27-0)
441	18147.522		
442	18147.390	7.390	P 23 (23-0)
443	18147.312	7.340	P112 (25-0)
		7.309	R 27 (23-0)
	18147.204	7.199	R170 (28-0)
444	18147.050	7.054	R 56 (26-1)
		7.014	R 94 (27-1)
445	18146.793	6.793	P 82 (24-0)
446	18146.732	6.732	P 24 (23-0)
		6.717	P167 (28-0)
447	18146.647	6.647	R 28 (23-0)
	18146.508		
448	18146.223	6.224	P 53 (26-1)
449	18146.163	6.163	R 86 (24-0)
450	18146.050	6.074	R138 (26-0)
		6.047	P 25 (23-0)
451	18145.963	5.989	R119 (28-1)
		5.983	R116 (25-0)
		5.963	P 91 (27-1)
		5.959	R 29 (23-0)
	18145.772		
452	18145.578	5.578	R 57 (26-1)
453	18145.337	5.386	R138 (29-1)
		5.338	P 26 (23-0)
454	18145.245	5.246	R 30 (23-0)
	18145.123	5.123	P116 (28-1)
	18144.941	4.940	P135 (29-1)
455	18144.735	4.734	P 54 (26-1)
456	18144.588	4.603	P 27 (23-0)
		4.582	P 83 (24-0)
		4.563	P135 (26-0)
457	18144.507	4.507	R 31 (23-0)
		4.452	R 95 (27-1)
458	18144.353	4.354	R156 (27-0)
459	18144.270	4.270	P113 (25-0)
460	18144.074	4.075	R 58 (26-1)
461	18143.941	3.941	R 87 (24-0)
462	18143.843	3.842	P 28 (23-0)
463	18143.743	3.743	R 32 (23-0)
	18143.497		
464	18143.395	3.394	P 92 (27-1)
465	18143.217	3.269	P153 (27-0)
		3.217	P 55 (26-1)
466	18143.055	3.056	P 29 (23-0)
467	18142.953	2.954	R 33 (23-0)
468	18142.897	2.894	R117 (25-0)
	18142.804		
469	18142.649	2.649	R120 (28-1)
470	18142.546	2.545	R 59 (26-1)
471	18142.343	2.344	P 84 (24-0)
		2.293	R139 (26-0)
472	18142.245	2.265	R171 (28-0)
		2.245	P 30 (23-0)
473	18142.138	2.139	R 34 (23-0)
474	18141.862	1.862	R 96 (27-1)
475	18141.786	1.796	P168 (28-0)
		1.782	P117 (28-1)
476	18141.687	1.693	R 88 (24-0)
		1.674	P 56 (26-1)
477	18141.408	1.408	P 31 (23-0)
		1.398	R139 (29-1)
478	18141.298	1.298	R 35 (23-0)
479	18141.171	1.172	P114 (25-0)
480	18140.987	0.989	R 60 (26-1)
		0.959	P136 (29-1)
481	18140.789	0.797	P 93 (27-1)
		0.779	P136 (26-0)
482	18140.547	0.546	P 32 (23-0)
483	18140.432	0.432	R 36 (23-0)
	18140.341		
484	18140.083	0.103	P 57 (26-1)
		0.080	P 85 (24-0)
485	18139.955	9.953	R157 (27-0)
486	18139.778	9.778	R118 (25-0)
487	18139.658	9.658	P 33 (23-0)
488	18139.541	9.541	R 37 (23-0)
489	18139.414	9.418	R 89 (24-0)
		9.405	R 61 (26-1)
490	18139.248	9.279	R121 (28-1)
		9.244	R 97 (27-1)



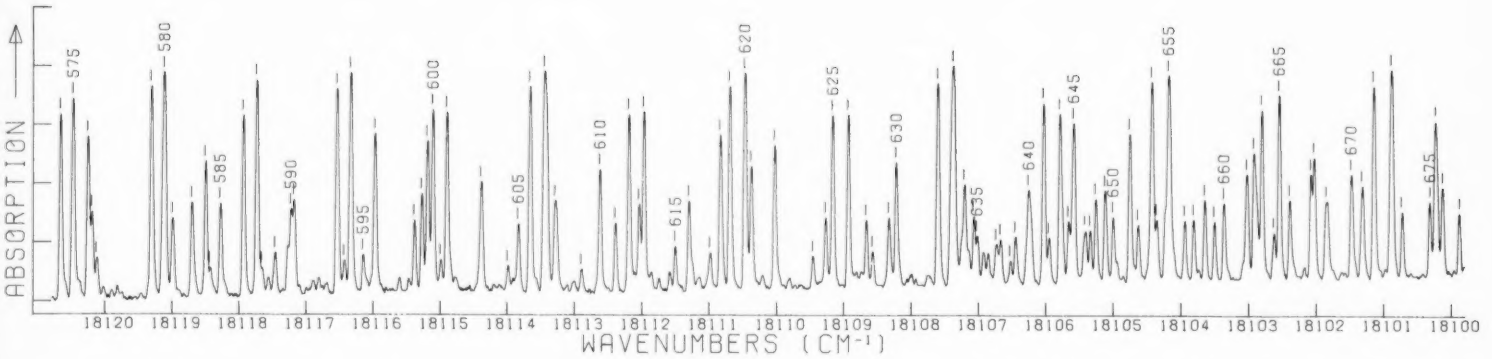
LINE	OBS CM-1	CALC	ASSIGNMENT
484	18140.083	0.103	P 57 (26-1)
		0.080	P 85 (24-0)
485	18139.955	9.953	R157 (27-0)
486	18139.778	9.778	R118 (25-0)
487	18139.658	9.658	P 33 (23-0)
488	18139.541	9.541	R 37 (23-0)
489	18139.414	9.418	R 89 (24-0)
		9.405	R 61 (26-1)
490	18139.248	9.279	R121 (28-1)
		9.244	R 97 (27-1)
491	18138.877	8.873	P154 (27-0)
492	18138.744	8.745	P 34 (23-0)
493	18138.622	8.623	R 38 (23-0)
494	18138.499	8.506	P 58 (26-1)
		8.482	R140 (26-0)
495	18138.409	8.412	P118 (28-1)
496	18138.170	8.172	P 94 (27-1)
497	18138.047	8.047	P115 (25-0)
498	18137.797	7.806	P 35 (23-0)
		7.794	R 62 (26-1)
		7.789	P 86 (24-0)
499	18137.680	7.681	R 39 (23-0)
	18137.385	7.380	R140 (29-1)
	18137.261	7.299	R172 (28-0)
500	18137.115	7.116	R 90 (24-0)
501	18136.963	6.966	P137 (26-0)
		6.947	P137 (29-1)
502	18136.844	6.882	P 59 (26-1)
		6.843	P169 (28-0)
		6.842	P 36 (23-0)
503	18136.712	6.713	R 40 (23-0)
504	18136.631	6.634	R119 (25-0)
		6.598	R 98 (27-1)
505	18136.156	6.156	R 63 (26-1)
	18136.067		

LINE	OBS CM-1	CALC	ASSIGNMENT
506	18135.852	5.880	R122 (28-1)
		5.852	P 37 (23-0)
507	18135.718	5.719	R 41 (23-0)
508	18135.473	5.522	R158 (27-0)
		5.519	P 95 (27-1)
		5.472	P 87 (24-0)
509	18135.231	5.230	P 60 (26-1)
510	18135.012	5.012	P119 (28-1)
	18134.894	4.894	P116 (25-0)
511	18134.789	4.837	P 38 (23-0)
		4.788	R 91 (24-0)
512	18134.699	4.700	R 42 (23-0)
	18134.645	4.642	R141 (26-0)
513	18134.490	4.491	R 64 (26-1)
		4.448	P155 (27-0)
	18134.333		
	18134.135		
514	18133.924	3.923	R 99 (27-1)
515	18133.796	3.796	P 39 (23-0)
516	18133.654	3.655	R 43 (23-0)
517	18133.552	3.552	P 61 (26-1)
518	18133.461	3.462	R120 (25-0)
	18133.328	3.330	R141 (29-1)
519	18133.128	3.129	P 88 (24-0)
		3.124	P138 (26-0)
	18132.909	2.905	P138 (29-1)
520	18132.801	2.838	P 96 (27-1)
521	18132.729	2.799	R 65 (26-1)
		2.730	P 40 (23-0)
522	18132.583	2.585	R 44 (23-0)
523	18132.434	2.451	R123 (28-1)
		2.433	R 92 (24-0)
	18132.299	2.301	R173 (28-0)
	18132.177		
	18131.934		

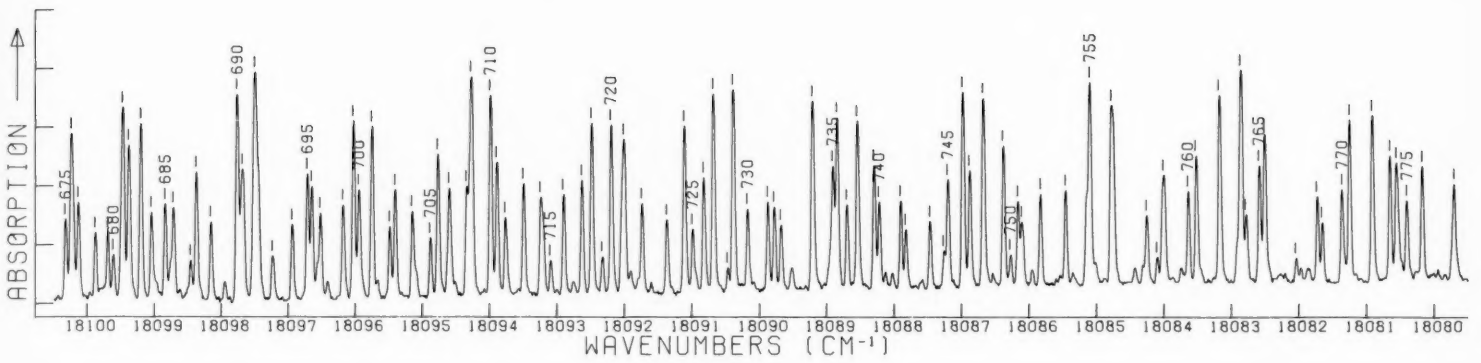
LINE	OBS CM-1	CALC	ASSIGNMENT
524	18131.848	1.859	P170 (28-0)
		1.847	P 62 (26-1)
525	18131.713	1.713	P117 (25-0)
526	18131.638	1.638	P 41 (23-0)
		1.584	P120 (28-1)
527	18131.488	1.489	R 45 (23-0)
	18131.319		
528	18131.221	1.221	R100 (27-1)
529	18131.077	1.080	R 66 (26-1)
		1.061	R159 (27-0)
530	18130.759	0.773	R142 (26-0)
		0.758	P 89 (24-0)
531	18130.520	0.521	P 42 (23-0)
532	18130.366	0.368	R 46 (23-0)
533	18130.263	0.263	R121 (25-0)
534	18130.118	0.128	P 97 (27-1)
		0.115	P 63 (26-1)
535	18130.051	0.052	R 93 (24-0)
		9.992	P156 (27-0)
	18129.606		
536	18129.377	9.379	P 43 (23-0)
		9.334	R 67 (26-1)
537	18129.220	9.254	P139 (26-0)
		9.250	R142 (29-1)
		9.221	R 47 (23-0)
	18129.055		
	18128.992	8.992	R124 (28-1)
	18128.833	8.832	P139 (29-1)
538	18128.710		
539	18128.500	8.505	P118 (25-0)
		8.490	R101 (27-1)
540	18128.358	8.362	P 90 (24-0)
		8.355	P 64 (26-1)
541	18128.210	8.210	P 44 (23-0)
542	18128.130	8.125	P121 (28-1)
543	18128.047	8.048	R 48 (23-0)
	18127.890		

LINE	OBS CM-1	CALC	ASSIGNMENT
544	18127.643	7.643	R 94 (24-0)
545	18127.561	7.560	R 68 (26-1)
546	18127.390	7.390	P 98 (27-1)
	18127.270	7.272	R174 (28-0)
547	18127.018	7.035	R122 (25-0)
		7.017	P 45 (23-0)
548	18126.851	6.875	R143 (26-0)
		6.850	R 49 (23-0)
		6.843	P171 (28-0)
	18126.730		
	18126.664		
549	18126.569	6.569	R160 (27-0)
		6.569	P 65 (26-1)
	18126.132		
550	18125.937	5.938	P 91 (24-0)
551	18125.795	5.797	P 46 (23-0)
		5.760	R 69 (26-1)
		5.730	R102 (27-1)
552	18125.626	5.626	R 50 (23-0)
553	18125.507	5.506	P157 (27-0)
		5.504	R125 (28-1)
554	18125.353	5.354	P140 (26-0)
555	18125.269	5.269	P119 (25-0)
556	18125.207	5.208	R 95 (24-0)
	18125.143	5.138	R143 (29-1)
557	18124.755	4.756	P 66 (26-1)
		4.728	P140 (29-1)
558	18124.625	4.638	P122 (28-1)
		4.625	P 99 (27-1)
559	18124.553	4.552	P 47 (23-0)
560	18124.375	4.377	R 51 (23-0)
	18124.059		
561	18123.933	3.933	R 70 (26-1)
562	18123.779	3.780	R123 (25-0)
563	18123.488	3.488	P 92 (24-0)
564	18123.281	3.282	P 48 (23-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
565	18123.100	3.102	R 52 (23-0)
566	18122.923	2.948	R144 (26-0)
		2.943	R103 (27-1)
		2.915	P 67 (26-1)
567	18122.746	2.747	R 96 (24-0)
	18122.502		
	18122.429		
	18122.204	2.210	R175 (28-0)
568	18122.077	2.078	R 71 (26-1)
		2.047	R161 (27-0)
569	18121.987	2.005	P120 (25-0)
		1.986	R126 (28-1)
		1.986	P 49 (23-0)
570	18121.800	1.831	P100 (27-1)
		1.801	R 53 (23-0)
		1.795	P172 (28-0)
	18121.638		
571	18121.426	1.425	P141 (26-0)
	18121.289		
572	18121.119	1.121	P123 (28-1)
573	18121.011	1.048	P 68 (26-1)
		1.012	P 93 (24-0)
		0.996	R144 (29-1)
		0.989	P158 (27-0)
574	18120.665	0.664	P 50 (23-0)
		0.594	P141 (29-1)
575	18120.477	0.496	R124 (25-0)
		0.475	R 54 (23-0)
	18120.384		
576	18120.256	0.258	R 97 (24-0)
577	18120.198	0.196	R 72 (26-1)
578	18120.129	0.127	R104 (27-1)
	18120.031		
	18119.911		
	18119.828		
	18119.766		



LINE	OBS CM-1	CALC	ASSIGNMENT
574	18120.665	0.664	P 50 (23-0)
		0.594	P141 (29-1)
575	18120.477	0.496	R124 (25-0)
		0.475	R 54 (23-0)
	18120.384		
576	18120.256	0.258	R 97 (24-0)
577	18120.198	0.196	R 72 (26-1)
578	18120.129	0.127	R104 (27-1)
	18120.031		
	18119.911		
	18119.828		
	18119.766		
	18119.479		
579	18119.317	9.317	P 51 (23-0)
580	18119.125	9.154	P 69 (26-1)
		9.123	R 55 (23-0)
581	18118.999	9.009	P101 (27-1)
		8.991	R145 (26-0)
582	18118.712	8.714	P121 (25-0)
583	18118.508	8.509	P 96 (24-0)
584	18118.443	8.439	R127 (26-1)
585	18118.288	8.287	R 73 (26-1)
586	18117.943	7.944	P 52 (23-0)
587	18117.743	7.745	R 56 (23-0)
		7.743	R 98 (24-0)
588	18117.667		
	18117.572	7.574	P124 (28-1)
589	18117.470	7.493	R162 (27-0)
		7.468	P142 (26-0)
590	18117.232	7.282	R105 (27-1)
		7.232	P 70 (26-1)
591	18117.188	7.185	R125 (25-0)
	18116.907		
	18116.821	6.822	R145 (29-1)
	18116.711	6.716	P173 (28-0)
592	18116.546	6.546	P 53 (23-0)
593	18116.440	6.442	P159 (27-0)
		6.428	P142 (29-1)
594	18116.344	6.351	R 74 (26-1)
		6.342	R 57 (23-0)
595	18116.157	6.158	P102 (27-1)
596	18115.977	5.979	P 95 (24-0)
	18115.617		
	18115.480		
597	18115.395	5.394	P122 (25-0)
598	18115.285	5.284	P 71 (26-1)
599	18115.201	5.201	R 99 (24-0)
600	18115.121	5.122	P 54 (23-0)
601	18115.003	5.006	R146 (26-0)
602	18114.911	4.913	R 58 (23-0)
		4.862	R128 (28-1)
	18114.787		
603	18114.392	4.409	R106 (27-1)
		4.388	R 75 (26-1)
604	18113.998	3.998	P125 (28-1)
605	18113.843	3.845	R126 (25-0)
606	18113.671	3.673	P 55 (23-0)
	18113.577		
607	18113.454	3.481	P143 (26-0)
		3.458	R 59 (23-0)
		3.422	P 96 (24-0)
608	18113.296	3.308	P 72 (26-1)
		3.279	P103 (27-1)
609	18112.907	2.909	R163 (27-0)
610	18112.629	2.632	R100 (24-0)
611	18112.398	2.397	R 76 (26-1)
612	18112.198	2.232	P143 (29-1)
		2.197	P 56 (23-0)
613	18112.047	2.047	P123 (25-0)
614	18111.977	1.978	R 60 (23-0)
	18111.869	1.865	P160 (27-0)
	18111.756		
	18111.592		
615	18111.508	1.508	R107 (27-1)
616	18111.304	1.305	P 73 (26-1)
		1.255	R129 (28-1)
	18111.152		
617	18110.988	0.990	R147 (26-0)
618	18110.837	0.839	P 97 (24-0)
619	18110.696	0.697	P 57 (23-0)
620	18110.472	0.478	R127 (25-0)
		0.472	R 61 (23-0)
621	18110.379	0.392	P126 (28-1)
		0.379	R 77 (26-1)
		0.372	P104 (27-1)
	18110.219		
622	18110.036	0.036	R101 (24-0)
	18109.823		
623	18109.464	9.465	P144 (26-0)
624	18109.276	9.275	P 74 (26-1)
625	18109.170	9.170	P 58 (23-0)
626	18108.940	8.940	R 62 (23-0)
627	18108.670	8.672	P124 (25-0)
628	18108.576	8.578	R108 (27-1)
629	18108.335	8.334	R 78 (26-1)
		8.295	R164 (27-0)
630	18108.227	8.229	P 98 (24-0)
	18108.009	8.005	P144 (29-1)
	18107.758		
631	18107.616	7.618	R130 (28-1)
		7.618	P 59 (23-0)
632	18107.386	7.440	R 1 (25-1)
		7.437	P105 (27-1)
		7.436	R 2 (25-1)
		7.418	R 0 (25-1)
		7.414	R102 (24-0)
		7.406	R 3 (25-1)
		7.383	R 63 (23-0)
		7.350	R 4 (25-1)
633	18107.219	7.295	P 1 (25-1)
		7.268	R 5 (25-1)
		7.257	P161 (27-0)
		7.218	P 75 (26-1)
		7.195	P 2 (25-1)
		7.159	R 6 (25-1)
634	18107.081	7.082	R128 (25-0)
		7.068	P 3 (25-1)
635	18107.032	7.025	R 7 (25-1)
	18106.938	6.946	R148 (26-0)
		6.916	P 4 (25-1)
	18106.865	6.864	R 8 (25-1)
636	18106.742	6.757	P127 (28-1)
		6.737	P 5 (25-1)
637	18106.680	6.677	R 9 (25-1)
638	18106.535	6.532	P 6 (25-1)
639	18106.460	6.464	R 10 (25-1)
640	18106.261	6.301	P 7 (25-1)
		6.262	R 79 (26-1)
		6.225	R 11 (25-1)
641	18106.041	6.043	P 8 (25-1)
		6.040	P 60 (23-0)
642	18105.962	5.960	R 12 (25-1)
643	18105.798	5.800	R 64 (23-0)
		5.760	P 9 (25-1)
		5.669	R 13 (25-1)
644	18105.669		
645	18105.594	5.620	R109 (27-1)
		5.592	P 99 (24-0)
646	18105.425	5.451	P 10 (25-1)
		5.420	P145 (26-0)
647	18105.352	5.351	R 14 (25-1)
648	18105.269	5.269	P125 (25-0)
649	18105.126	5.134	P 76 (26-1)
		5.115	P 11 (25-1)
650	18105.009	5.008	R 15 (25-1)
651	18104.761	4.765	R103 (24-0)
		4.753	P 12 (25-1)
652	18104.638	4.638	R 16 (25-1)
653	18104.436	4.474	P106 (27-1)
		4.437	P 61 (23-0)
654	18104.368	4.365	P 13 (25-1)
655	18104.187	4.242	R 17 (25-1)
		4.191	R 65 (23-0)
		4.163	R 80 (26-1)
656	18103.952	3.952	R131 (28-1)
		3.951	P 14 (25-1)
657	18103.820	3.820	R 18 (25-1)
	18103.749	3.747	P145 (29-1)
658	18103.656	3.659	R129 (25-0)
		3.649	R165 (27-0)
659	18103.511	3.511	P 15 (25-1)
660	18103.371	3.372	R 19 (25-1)
661	18103.029	3.092	P128 (28-1)
		3.045	P 16 (25-1)
		3.022	P 77 (26-1)
662	18102.925	2.929	P100 (24-0)
		2.897	R 20 (25-1)
		2.872	R149 (26-0)
663	18102.808	2.808	P 62 (23-0)
664	18102.632	2.633	R110 (27-1)
		2.618	P162 (27-0)
665	18102.554	2.556	R 66 (23-0)
		2.553	P 17 (25-1)
666	18102.397	2.397	R 21 (25-1)
	18102.187		
667	18102.086	2.088	R104 (24-0)
668	18102.036	2.036	R 81 (26-1)
		2.034	P 18 (25-1)
669	18101.850	1.870	R 22 (25-1)
		1.838	P126 (25-0)
	18101.628		
670	18101.485	1.489	P 19 (25-1)
		1.482	P107 (27-1)
671	18101.320	1.345	P146 (26-0)
		1.317	R 23 (25-1)
672	18101.152	1.153	P 63 (23-0)
673	18100.895	0.919	P 20 (25-1)
		0.895	R 67 (23-0)
		0.883	P 78 (26-1)
674	18100.738	0.738	R 24 (25-1)
675	18100.322	0.322	P 21 (25-1)
676	18100.236	0.256	R132 (28-1)
		0.239	P101 (24-0)
		0.207	R130 (25-0)
677	18100.132	0.133	R 25 (25-1)
678	18099.881	9.881	R 82 (26-1)



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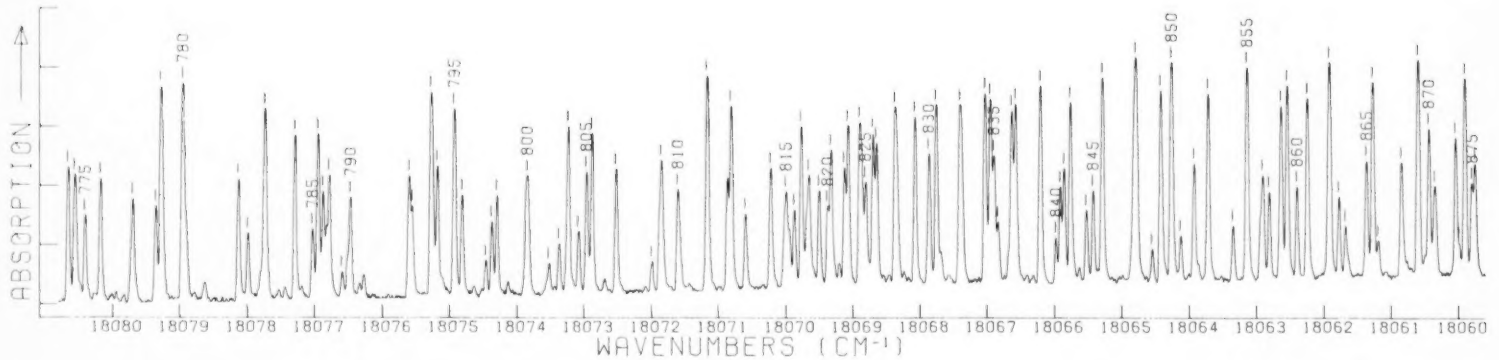
675	18100.322	0.322	P 21 (25-1)
676	18100.236	0.256	R132 (28-1)
		0.239	P101 (24-0)
		0.207	R130 (25-0)
677	18100.132	0.133	R 25 (25-1)
678	18099.881	9.881	R 82 (26-1)
679	18099.699	9.698	P 22 (25-1)
680	18099.617	9.618	R111 (27-1)
681	18099.474	9.501	R 26 (25-1)
		9.472	P 64 (23-0)
		9.458	P146 (29-1)
682	18099.384	9.398	P129 (28-1)
		9.385	R105 (24-0)
683	18099.208	9.209	R 68 (23-0)
684	18099.049	9.049	P 23 (25-1)
		8.973	R166 (27-0)
685	18098.844	8.844	R 27 (25-1)
686	18098.720	8.768	R150 (26-0)
		8.717	P 79 (26-1)
	18098.622		
687	18098.461	8.461	P108 (27-1)
688	18098.375	8.379	P127 (25-0)
		8.374	P 24 (25-1)
689	18098.160	8.160	R 28 (25-1)
	18097.950	7.949	P163 (27-0)
690	18097.766	7.766	P 65 (23-0)
691	18097.685	7.700	R 83 (26-1)
		7.672	P 25 (25-1)
692	18097.501	7.522	P102 (24-0)
		7.497	R 69 (23-0)
		7.450	R 29 (25-1)
693	18097.237	7.242	P147 (26-0)
694	18096.945	6.944	P 26 (25-1)
695	18096.719	6.727	R131 (25-0)
		6.714	R 30 (25-1)
696	18096.654	6.655	R106 (24-0)
697	18096.525	6.574	R112 (27-1)
		6.529	R133 (28-1)
		6.524	P 80 (26-1)
698	18096.190	6.190	P 27 (25-1)
699	18096.033	6.034	P 66 (23-0)
700	18095.953	5.951	R 31 (25-1)
701	18095.759	5.759	R 70 (23-0)
	18095.673	5.673	P130 (28-1)
702	18095.491	5.491	R 84 (26-1)
703	18095.410	5.412	P109 (27-1)
		5.410	P 28 (25-1)
704	18095.162	5.162	R 32 (25-1)
		5.137	P147 (29-1)
705	18094.891	4.892	P128 (25-0)
706	18094.778	4.778	P103 (24-0)
707	18094.605	4.635	R151 (26-0)
		4.604	P 29 (25-1)
	18094.517		
708	18094.346	4.348	R 33 (25-1)
709	18094.277	4.304	P 81 (26-1)
		4.276	P 67 (23-0)
		4.265	R167 (27-0)
710	18093.994	3.995	R 71 (23-0)
711	18093.897	3.898	R107 (24-0)
712	18093.771	3.771	P 30 (25-1)
713	18093.505	3.506	R 34 (25-1)
		3.502	R113 (27-1)
714	18093.252	3.255	R 85 (26-1)
		3.250	P164 (27-0)
		3.219	R132 (25-0)
715	18093.106	3.109	P148 (26-0)
716	18092.914	2.913	P 31 (25-1)
	18092.771	2.773	R134 (28-1)
717	18092.640	2.639	R 35 (25-1)
718	18092.492	2.493	P 68 (23-0)
719	18092.334	2.335	P110 (27-1)
720	18092.204	2.206	R 72 (23-0)
721	18092.015	2.056	P 82 (26-1)
		2.028	P 32 (25-1)
		2.007	P104 (24-0)
	18091.917	1.919	P131 (28-1)
722	18091.747	1.746	R 36 (25-1)
	18091.613		
723	18091.376	1.377	P129 (25-0)
724	18091.114	1.117	P 33 (25-1)
		1.114	R108 (24-0)
725	18090.991	0.991	R 86 (26-1)
726	18090.826	0.826	R 37 (25-1)
		0.786	P148 (29-1)
727	18090.683	0.683	P 69 (23-0)
728	18090.471	0.472	R152 (26-0)
729	18090.390	0.401	R114 (27-1)
		0.390	R 73 (23-0)
730	18090.180	0.179	P 34 (25-1)
731	18089.880	9.880	R 38 (25-1)
732	18089.783	9.781	P 83 (26-1)
733	18089.682	9.683	R133 (25-0)
	18089.523	9.527	R168 (27-0)
734	18089.212	9.229	P111 (27-1)
		9.216	P 35 (25-1)
		9.210	P105 (24-0)
735	18088.910	8.987	R135 (28-1)
		8.947	P149 (26-0)
		8.907	R 39 (25-1)
736	18088.848	8.848	P 70 (23-0)
737	18088.701	8.700	R 87 (26-1)
738	18088.548	8.549	R 74 (23-0)
		8.519	P165 (27-0)
739	18088.302	8.303	R109 (24-0)
740	18088.226	8.226	P 36 (25-1)
	18088.135	8.136	P132 (28-1)
	18088.034		
741	18087.909	7.908	R 40 (25-1)
742	18087.832	7.834	P130 (25-0)
	18087.606		
743	18087.478	7.479	P 84 (26-1)
744	18087.269	7.271	R115 (27-1)
745	18087.210	7.210	P 37 (25-1)
746	18086.987	6.988	P 71 (23-0)
747	18086.884	6.884	R 41 (25-1)
748	18086.682	6.682	R 75 (23-0)
	18086.541		
749	18086.385	6.403	P149 (29-1)
		6.386	P106 (24-0)
		6.381	R 88 (26-1)
750	18086.280	6.280	R153 (26-0)
751	18086.167	6.168	P 38 (25-1)
752	18086.110	6.118	R134 (25-0)
		6.095	P112 (27-1)
	18085.957		
753	18085.833	5.832	R 42 (25-1)
754	18085.464	5.465	R110 (24-0)
	18085.354		
755	18085.101	5.171	R136 (28-1)
		5.150	P 85 (26-1)
		5.101	P 72 (23-0)
		5.099	P 39 (25-1)
	18085.019		
	18084.899		
756	18084.779	4.789	R 76 (23-0)
		4.758	R169 (27-0)
		4.755	P150 (26-0)
		4.755	R 43 (25-1)
	18084.434		
	18084.319	4.322	P133 (28-1)
757	18084.261	4.263	P131 (25-0)
758	18084.108	4.112	R116 (27-1)
759	18084.013	4.035	R 89 (26-1)
		4.005	P 40 (25-1)
	18083.884		
	18083.606	3.758	P166 (27-0)
760	18083.652	3.651	R 44 (25-1)
761	18083.533	3.534	P107 (24-0)
762	18083.187	3.189	P 73 (23-0)
763	18082.873	2.932	P113 (27-1)
		2.884	P 41 (25-1)
		2.870	R 77 (23-0)
764	18082.793	2.793	P 86 (26-1)
765	18082.599	2.600	R111 (24-0)
766	18082.523	2.526	R135 (25-0)
		2.521	R 45 (25-1)
767	18082.054	2.058	R154 (26-0)
	18081.986	1.990	P150 (29-1)
768	18081.737	1.736	P 42 (25-1)
769	18081.664	1.662	R 90 (26-1)
770	18081.365	1.364	R 46 (25-1)
		1.325	R137 (28-1)
771	18081.250	1.250	P 74 (23-0)
772	18080.924	0.925	R117 (27-1)
		0.925	R 78 (23-0)
773	18080.658	0.664	P132 (25-0)
		0.656	P108 (24-0)
774	18080.562	0.563	P 43 (25-1)
		0.534	P151 (26-0)
		0.479	P134 (28-1)
775	18080.409	0.408	P 87 (26-1)
	18080.276		
776	18080.182	0.182	R 47 (25-1)
	18080.024		
	18079.951	9.957	R170 (27-0)
	18079.844		
777	18079.708	9.741	P114 (27-1)
		9.707	R112 (24-0)



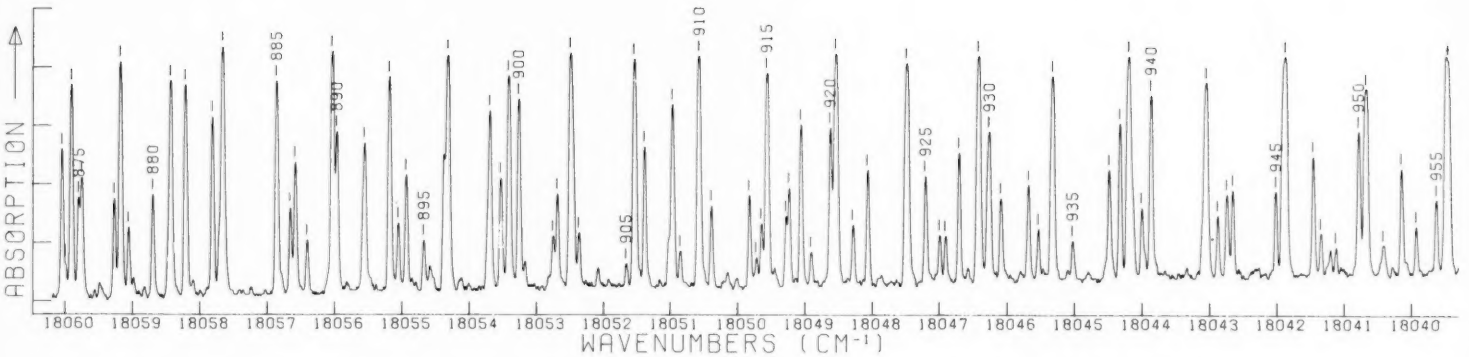
LINE	OBS CM-1	CALC	ASSIGNMENT
773	18080.658	0.664	P132 (25-0)
		0.656	P108 (24-0)
774	18080.562	0.563	P 43 (25-1)
		0.534	P151 (26-0)
		0.479	P134 (28-1)
775	18080.409	0.408	P 87 (26-1)
	18080.276		
776	18080.182	0.182	R 47 (25-1)
	18080.024		
	18079.951	9.957	R170 (27-0)
	18079.844		
777	18079.708	9.741	P114 (27-1)
		9.707	R112 (24-0)
778	18079.364	9.363	P 44 (25-1)
779	18079.282	9.286	P 75 (23-0)
		9.261	R 91 (26-1)
780	18078.958	8.972	R 48 (25-1)
		8.966	P167 (27-0)
		8.954	R 79 (23-0)
		8.904	R136 (25-0)
	18078.803		
	18078.639		
781	18078.137	8.137	P 45 (25-1)
782	18077.998	7.997	P 88 (26-1)
783	18077.743	7.807	R155 (26-0)
		7.751	P109 (24-0)
		7.737	R 49 (25-1)
		7.709	R118 (27-1)
	18077.543	7.545	P151 (29-1)
	18077.443	7.448	R138 (28-1)
784	18077.296	7.296	P 76 (23-0)
	18077.198		
785	18077.037	7.036	P133 (25-0)
786	18076.957	6.958	R 80 (23-0)
787	18076.885	6.884	P 46 (25-1)
788	18076.789	6.833	R 92 (26-1)
		6.788	R113 (24-0)
789	18076.603	6.605	P135 (28-1)
790	18076.477	6.521	P115 (27-1)
		6.475	R 50 (25-1)
	18076.347		
	18076.282	6.284	P152 (26-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
791	18075.606	5.606	P 47 (25-1)
792	18075.563	5.558	P 89 (26-1)
793	18075.278	5.281	P 77 (23-0)
		5.255	R137 (25-0)
794	18075.187	5.187	R 51 (25-1)
795	18074.934	4.935	R 81 (23-0)
796	18074.818	4.819	P110 (24-0)
	18074.645		
797	18074.465	4.465	R119 (27-1)
798	18074.377	4.377	R 93 (26-1)
799	18074.301	4.361	P 48 (25-1)
	18074.144	4.143	P168 (27-0)
800	18073.856	3.872	R 52 (25-1)
		3.842	R114 (24-0)
801	18073.532	3.542	R139 (28-1)
		3.526	R156 (26-0)
	18073.458		
802	18073.379	3.381	P134 (25-0)
803	18073.240	3.273	P116 (27-1)
		3.239	P 78 (23-0)
804	18073.091	3.091	P 90 (26-1)
		3.068	P152 (29-1)
805	18072.970	2.969	P 49 (25-1)
806	18072.886	2.886	R 82 (23-0)
	18072.700	2.702	P136 (28-1)
807	18072.531	2.531	R 53 (25-1)
	18072.101		
808	18071.999	2.004	P153 (26-0)
809	18071.861	1.893	R 94 (26-1)
		1.860	P111 (24-0)
810	18071.610	1.612	P 50 (25-1)
		1.577	R138 (25-0)
811	18071.170	1.191	R120 (27-1)
		1.171	P 79 (23-0)
		1.164	R 54 (25-1)
	18070.866	0.868	R115 (24-0)
812	18070.811	0.812	R 83 (23-0)
813	18070.599	0.598	P 91 (26-1)
814	18070.230	0.228	P 51 (25-1)

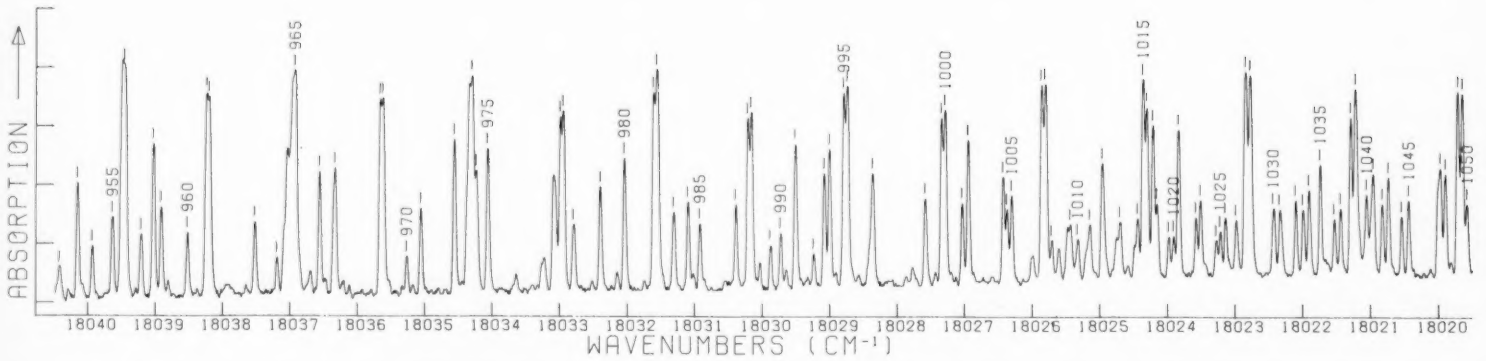
LINE	OBS CM-1	CALC	ASSIGNMENT
815	18070.006	0.030	R 1 (22-0)
		0.030	R 2 (22-0)
		0.006	R 0 (22-0)
		0.005	R 3 (22-0)
		9.996	P117 (27-1)
		9.955	R 4 (22-0)
	18067.692	7.694	P154 (26-0)
816	18069.880	9.881	P 1 (22-0)
		9.880	R 5 (22-0)
817	18069.774	9.782	P 2 (22-0)
		9.781	R 6 (22-0)
		9.770	R 55 (25-1)
818	18069.659	9.697	P135 (25-0)
		9.657	P 3 (22-0)
		9.656	R 7 (22-0)
		9.605	R140 (28-1)
819	18069.506	9.508	P 4 (22-0)
		9.506	R 8 (22-0)
820	18069.383	9.382	R 95 (26-1)
821	18069.331	9.333	P 5 (22-0)
		9.332	R 9 (22-0)
		9.289	P169 (27-0)
	18069.213	9.215	R157 (26-0)
822	18069.131	9.134	P 6 (22-0)
		9.132	R 10 (22-0)
823	18069.079	9.078	P 80 (23-0)
824	18068.904	8.910	P 7 (22-0)
		8.908	R 11 (22-0)
		8.874	P112 (24-0)
825	18068.819	8.817	P 52 (25-1)
		8.769	P137 (28-1)
826	18068.711	8.711	R 84 (23-0)
827	18068.660	8.661	P 8 (22-0)
		8.658	R 12 (22-0)
	18068.560	8.560	P153 (29-1)
	18068.475		
828	18068.380	8.387	P 9 (22-0)
		8.384	R 13 (22-0)
		8.350	R 56 (25-1)
	18068.252		
829	18068.083	8.088	P 10 (22-0)
		8.085	R 14 (22-0)
		8.076	P 92 (26-1)

LINE	OBS CM-1	CALC	ASSIGNMENT
830	18067.870	7.889	R121 (27-1)
		7.871	R139 (25-0)
		7.868	R116 (24-0)
831	18067.761	7.764	P 11 (22-0)
		7.760	R 15 (22-0)
		7.694	P154 (26-0)
	18067.573		
832	18067.404	7.415	P 12 (22-0)
		7.411	R 16 (22-0)
		7.381	P 53 (25-1)
833	18067.037	7.041	P 13 (22-0)
		7.037	R 17 (22-0)
834	18066.958	6.959	P 81 (23-0)
835	18066.906	6.903	R 57 (25-1)
836	18066.846	6.843	R 96 (26-1)
837	18066.639	6.690	P118 (27-1)
		6.643	P 14 (22-0)
		6.638	R 18 (22-0)
838	18066.584	6.584	R 85 (23-0)
	18066.423		
	18066.331		
839	18066.215	6.219	P 15 (22-0)
		6.214	R 19 (22-0)
840	18065.986	5.986	P136 (25-0)
841	18065.918	5.917	P 54 (25-1)
842	18065.861	5.861	P113 (24-0)
843	18065.767	5.771	P 16 (22-0)
		5.765	R 20 (22-0)
	18065.637	5.638	R141 (28-1)
844	18065.530	5.527	P 93 (26-1)
845	18065.432	5.430	R 58 (25-1)
846	18065.292	5.297	P 17 (22-0)
		5.291	R 21 (22-0)
847	18064.803	4.874	R158 (26-0)
		4.840	R117 (24-0)
		4.813	P 82 (23-0)
		4.806	P138 (28-1)
		4.799	P 18 (22-0)
		4.793	R 22 (22-0)
848	18064.559	4.557	R122 (27-1)
849	18064.430	4.431	R 86 (23-0)
		4.428	P 55 (25-1)
		4.405	P170 (27-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
850	18064.271	4.277	R 97 (26-1)
		4.276	P 19 (22-0)
		4.269	R 23 (22-0)
851	18064.135	4.136	R140 (25-0)
	18064.020	4.021	P154 (29-1)
852	18063.932	3.930	R 59 (25-1)
853	18063.723	3.727	P 20 (22-0)
		3.720	R 24 (22-0)
854	18063.354	3.355	P155 (26-0)
		3.355	P119 (27-1)
855	18063.149	3.154	P 21 (22-0)
		3.146	R 25 (22-0)
856	18062.916	2.951	P 94 (26-1)
		2.912	P 56 (25-1)
857	18062.821	2.821	P114 (24-0)
858	18062.643	2.642	P 83 (23-0)
859	18062.551	2.556	P 22 (22-0)
		2.547	R 26 (22-0)
860	18062.406	2.404	R 60 (25-1)
861	18062.251	2.253	R 87 (23-0)
		2.246	P137 (25-0)
862	18061.927	1.933	P 23 (22-0)
		1.924	R 27 (22-0)
863	18061.785	1.785	R118 (24-0)
864	18061.685	1.683	R 98 (26-1)
		1.641	R142 (28-1)
865	18061.372	1.370	P 57 (25-1)
866	18061.279	1.285	P 24 (22-0)
		1.275	R 28 (22-0)
867	18061.197	1.197	R123 (27-1)
868	18060.853	0.852	R 61 (25-1)
		0.812	P139 (28-1)
869	18060.606	0.612	P 25 (22-0)
		0.601	R 29 (22-0)
870	18060.445	0.503	R159 (26-0)
		0.445	P 84 (23-0)
871	18060.356	0.373	R141 (25-0)
		0.347	P 95 (26-1)
872	18060.048	0.048	R 88 (23-0)
873	18059.997	9.992	P120 (27-1)
874	18059.907	9.914	P 26 (22-0)
		9.903	R 30 (22-0)
875	18059.802	9.801	P 58 (25-1)
876	18059.755	9.754	P115 (24-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
872	18060.048	0.048	R 88 (23-0)
873	18059.997	9.992	P120 (27-1)
874	18059.907	9.914	P 26 (22-0)
		9.903	R 30 (22-0)
875	18059.802	9.801	P 58 (25-1)
876	18059.755	9.754	P115 (24-0)
	18059.568		
	18059.488	9.489	P171 (27-0)
877	18059.274	9.273	R 62 (25-1)
878	18059.183	9.191	P 27 (22-0)
		9.179	R 31 (22-0)
879	18059.063	9.062	R 99 (26-1)
	18058.986	8.987	P156 (26-0)
	18058.910		
	18058.827		
880	18058.702	8.702	R119 (24-0)
881	18058.435	8.477	P138 (25-0)
		8.443	P 28 (22-0)
		8.430	R 32 (22-0)
882	18058.217	8.222	P 85 (23-0)
		8.206	P 59 (25-1)
	18058.104		
	18057.995		
883	18057.816	7.817	R 89 (23-0)
		7.808	R124 (27-1)
884	18057.663	7.716	P 96 (26-1)
		7.670	P 29 (22-0)
		7.667	R 63 (25-1)
		7.656	R 33 (22-0)
		7.613	R143 (28-1)
	18057.249		
	18057.040		
885	18056.864	6.872	P 30 (22-0)
		6.858	R 34 (22-0)
		6.789	P140 (28-1)
886	18056.660	6.660	P116 (24-0)
887	18056.586	6.600	P121 (27-1)
		6.585	P 60 (25-1)
		6.581	R142 (25-0)
888	18056.413	6.412	R100 (26-1)
889	18056.040	6.103	R160 (26-0)
		6.049	P 31 (22-0)
		6.035	R 64 (25-1)
		6.034	R 35 (22-0)
890	18055.974	5.973	P 86 (23-0)
	18055.831		
891	18055.563	5.593	R120 (24-0)
		5.560	R 90 (23-0)
892	18055.193	5.201	P 32 (22-0)
		5.185	R 36 (22-0)
893	18055.060	5.057	P 87 (26-1)
894	18054.939	4.937	P 61 (25-1)
895	18054.681	4.681	P139 (25-0)
	18054.588	4.589	P157 (26-0)
		4.542	P172 (27-0)
	18054.375	4.390	R125 (27-1)
		4.376	R 65 (25-1)
896	18054.318	4.328	P 33 (22-0)
		4.311	R 37 (22-0)
	18054.122		
897	18053.700	3.735	R101 (26-1)
		3.698	P 87 (23-0)
898	18053.539	3.556	R144 (28-1)
		3.538	P117 (24-0)
899	18053.420	3.430	P 34 (22-0)
		3.413	R 38 (22-0)
900	18053.272	3.277	R 91 (23-0)
		3.262	P 62 (25-1)
	18053.179	3.180	P122 (27-1)
901	18052.758	2.761	R143 (25-0)
		2.736	P141 (28-1)
902	18052.694	2.691	R 66 (25-1)
903	18052.495	2.507	R 35 (22-0)
		2.489	R 39 (22-0)
		2.456	R121 (24-0)
904	18052.373	2.371	P 98 (26-1)
	18052.085		
	18051.926		
905	18051.674	1.672	R161 (26-0)
906	18051.551	1.561	P 63 (25-1)
		1.560	P 36 (22-0)
		1.540	R 40 (22-0)
907	18051.397	1.397	P 88 (23-0)
908	18050.973	1.031	R102 (26-1)
		0.980	R 67 (25-1)
		0.967	R 92 (23-0)
		0.943	R126 (27-1)
909	18050.856	0.856	R140 (25-0)
910	18050.574	0.587	P 37 (22-0)
		0.566	R 41 (22-0)
911	18050.390	0.390	P118 (24-0)
	18050.159	0.161	P158 (26-0)
	18050.024		
912	18049.836	9.834	P 64 (25-1)
913	18049.732	9.730	P123 (27-1)
914	18049.659	9.657	P 99 (26-1)
915	18049.576	9.589	P 38 (22-0)
		9.567	R 42 (22-0)
		9.565	P173 (27-0)
	18049.462	9.467	R145 (28-1)
916	18049.291	9.292	R122 (24-0)
917	18049.245	9.241	R 68 (25-1)
918	18049.070	9.069	P 89 (23-0)
919	18048.917	8.912	R144 (25-0)
920	18048.633	8.652	P142 (28-1)
		8.632	R 93 (23-0)
921	18048.551	8.566	P 39 (22-0)
		8.542	R 43 (22-0)
922	18048.300	8.298	R103 (26-1)
923	18048.082	8.080	P 65 (25-1)
924	18047.496	7.518	P 40 (22-0)
		7.493	R 44 (22-0)
		7.476	R 69 (25-1)
		7.467	R127 (27-1)
925	18047.214	7.214	P119 (24-0)
		7.212	R162 (26-0)
926	18047.003	7.002	P141 (25-0)
927	18046.917	6.915	P100 (26-1)
928	18046.717	6.716	P 90 (23-0)
	18046.584		
929	18046.429	6.445	P 41 (22-0)
		6.419	R 45 (22-0)
930	18046.274	6.300	P 66 (25-1)
		6.270	R 94 (23-0)
		6.252	P124 (27-1)
931	18046.100	6.100	R123 (24-0)
932	18045.689	5.703	P159 (26-0)
		5.685	R 70 (25-1)
933	18045.542	5.538	R104 (26-1)
934	18045.332	5.349	R146 (28-1)
		5.347	P 42 (22-0)
		5.320	R 46 (22-0)
	18045.105		
935	18045.035	5.035	R145 (25-0)
	18044.796		
936	18044.495	4.556	P174 (27-0)
		4.538	P143 (28-1)
		4.493	P 67 (25-1)
937	18044.338	4.337	P 91 (23-0)
938	18044.205	4.224	P 43 (22-0)
		4.195	R 47 (22-0)
		4.146	P101 (26-1)
939	18044.012	4.011	P120 (24-0)
		3.962	R128 (27-1)
940	18043.877	3.882	R 95 (23-0)
		3.867	R 71 (25-1)
941	18043.060	3.120	P142 (25-0)
		3.076	P 44 (22-0)
		3.045	R 48 (22-0)
942	18042.883	2.881	R124 (24-0)
943	18042.749	2.750	R105 (26-1)
		2.744	P125 (27-1)
		2.721	R163 (26-0)
944	18042.662	2.659	P 68 (25-1)
945	18042.026	2.022	R 72 (25-1)
946	18041.883	1.931	P 92 (23-0)
		1.902	P 45 (22-0)
		1.871	R 49 (22-0)
947	18041.470	1.468	R 96 (23-0)
948	18041.353	1.349	P102 (26-1)
	18041.208	1.216	P160 (26-0)
		1.200	R147 (28-1)
949	18041.129	1.129	R146 (25-0)
950	18040.794	0.799	P 69 (25-1)
		0.781	P121 (24-0)
951	18040.681	0.704	P 46 (22-0)
		0.671	R 50 (22-0)
952	18040.425	0.428	R129 (27-1)
		0.394	P144 (28-1)
	18040.292		
953	18040.155	0.151	R 73 (25-1)
954	18039.935	9.934	R106 (26-1)
955	18039.637	9.635	R125 (24-0)
956	18039.462	9.515	P175 (27-0)
		9.500	P 93 (23-0)
		9.481	P 47 (22-0)
		9.446	R 51 (22-0)



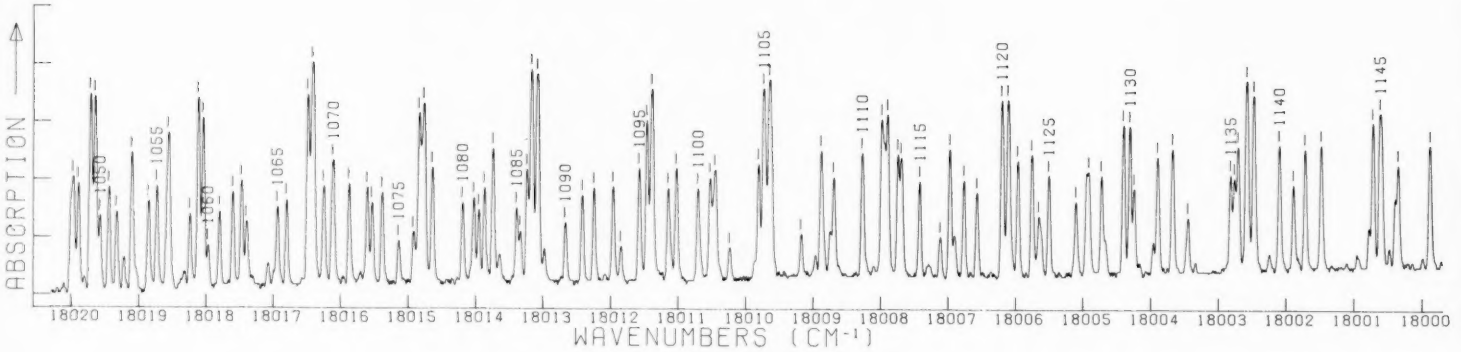
LINE	OBS CM-1	CALC	ASSIGNMENT
952	18040.425	0.428	R129 (27-1)
		0.394	P144 (28-1)
	18040.292		
953	18040.155	0.151	R 73 (25-1)
954	18039.935	9.934	R106 (26-1)
955	18039.637	9.635	R125 (24-0)
956	18039.462	9.515	P175 (27-0)
		9.500	P 93 (23-0)
		9.481	P 47 (22-0)
		9.446	R 51 (22-0)
957	18039.212	9.210	P143 (25-0)
		9.208	P126 (27-1)
958	18039.030	9.028	R 97 (23-0)
959	18038.916	8.913	P 70 (25-1)
	18038.812		
960	18038.526	8.524	P103 (26-1)
961	18038.236	8.253	R 74 (25-1)
		8.232	P 48 (22-0)
962	18038.203	8.201	R164 (26-0)
		8.196	R 52 (22-0)
	18037.655		
963	18037.524	7.524	P122 (24-0)
964	18037.197	7.194	R147 (25-0)
965	18036.927	7.090	R107 (26-1)
		7.042	P 94 (23-0)
		7.020	R148 (28-1)
		7.000	P 71 (25-1)
		6.959	P 49 (22-0)
		6.920	R 53 (22-0)
		6.865	R130 (27-1)
	18036.700	6.699	P161 (26-0)
966	18036.563	6.562	R 98 (23-0)
	18036.480		
967	18036.335	6.361	R126 (24-0)
		6.328	R 75 (25-1)
	18036.220	6.220	P145 (28-1)
	18036.126		

LINE	OBS CM-1	CALC	ASSIGNMENT
968	18035.661	5.672	P104 (26-1)
		5.660	P 50 (22-0)
		5.643	P127 (27-1)
969	18035.625	5.620	R 54 (22-0)
970	18035.273	5.271	P144 (25-0)
	18035.185		
971	18035.062	5.060	P 72 (25-1)
972	18034.560	4.559	P 95 (23-0)
		4.444	P176 (27-0)
		4.377	R 76 (25-1)
973	18034.299	4.337	P 51 (22-0)
		4.294	R 55 (22-0)
974	18034.239	4.240	P123 (24-0)
		4.219	R108 (26-1)
975	18034.070	4.069	R 99 (23-0)
	18033.650	3.650	R165 (26-0)
	18033.231	3.272	R131 (27-1)
		3.230	R148 (25-0)
	18033.080	3.094	P 73 (25-1)
		3.060	R127 (24-0)
976	18032.989	2.988	P 52 (22-0)
977	18032.947	2.944	R 56 (22-0)
978	18032.795	2.810	R149 (28-1)
		2.792	P105 (26-1)
	18032.524		
979	18032.402	2.399	R 77 (25-1)
	18032.154	2.151	P162 (26-0)
980	18032.050	2.049	P128 (27-1)
		2.049	P 96 (23-0)
		2.015	P146 (28-1)
	18031.758		
981	18031.615	1.614	P 53 (22-0)
982	18031.566	1.568	R 57 (22-0)
		1.550	R100 (23-0)
983	18031.315	1.319	R109 (26-1)
		1.304	P145 (25-0)
984	18031.104	1.101	P 74 (25-1)
	18031.023		
985	18030.928	0.928	P124 (24-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
	18030.554		
986	18030.397	0.394	R 78 (25-1)
987	18030.216	0.215	P 54 (22-0)
988	18030.168	0.166	R 58 (22-0)
989	18029.886	9.884	P106 (26-1)
990	18029.734	9.731	R128 (24-0)
	18029.650	9.650	R132 (27-1)
991	18029.514	9.513	P 97 (23-0)
	18029.337	9.341	P177 (27-0)
992	18029.240	9.238	R149 (25-0)
993	18029.083	9.081	P 75 (25-1)
		9.069	R166 (26-0)
994	18029.006	9.005	R101 (23-0)
	18028.915		
995	18028.794	8.790	P 55 (22-0)
996	18028.742	8.740	R 59 (22-0)
	18028.573	8.569	R150 (28-1)
997	18028.368	8.426	P129 (27-1)
		8.392	R110 (26-1)
		8.363	R 79 (25-1)
	18027.866		
	18027.774	7.780	P147 (28-1)
998	18027.588	7.589	P125 (24-0)
		7.574	P163 (26-0)
	18027.431		
999	18027.343	7.341	P 56 (22-0)
1000	18027.290	7.308	P146 (25-0)
		7.288	R 60 (22-0)
1001	18027.037	7.035	P 76 (25-1)
1002	18026.952	6.951	P 98 (23-0)
		6.948	P107 (26-1)
1003	18026.434	6.433	R102 (23-0)
1004	18026.378	6.375	R129 (24-0)
1005	18026.310	6.304	R 80 (25-1)
	18026.003	6.000	R133 (27-1)
1006	18025.869	5.879	R 1 (24-1)
		5.876	R 2 (24-1)
		5.867	P 57 (22-0)
		5.856	R 0 (24-1)
		5.848	R 3 (24-1)

LINE	OBS CM-1	CALC	ASSIGNMENT
1007	18025.814	5.812	R 61 (22-0)
		5.794	R 4 (24-1)
1008	18025.719	5.732	P 1 (24-1)
		5.715	R 5 (24-1)
	18025.611	5.632	P 2 (24-1)
		5.610	R 6 (24-1)
	18025.482	5.507	P 3 (24-1)
		5.479	R 7 (24-1)
1009	18025.442	5.436	R111 (26-1)
1010	18025.329	5.355	P 4 (24-1)
		5.323	R 8 (24-1)
1011	18025.147	5.217	R150 (25-0)
		5.179	P 5 (24-1)
		5.141	R 9 (24-1)
1012	18024.964	4.976	P 6 (24-1)
		4.962	P 77 (25-1)
		4.933	R 10 (24-1)
	18024.752	4.774	P130 (27-1)
		4.748	P 7 (24-1)
1013	18024.703	4.700	R 11 (24-1)
	18024.591		
1014	18024.448	4.494	P 8 (24-1)
		4.458	R167 (26-0)
		4.441	R 12 (24-1)
1015	18024.366	4.367	P 58 (22-0)
		4.362	P 99 (23-0)
1016	18024.311	4.310	R 62 (22-0)
1017	18024.221	4.222	P126 (24-0)
		4.219	R 81 (25-1)
		4.215	P 9 (24-1)
1018	18024.162	4.157	R 13 (24-1)
1019	18023.987	3.985	P108 (26-1)
1020	18023.913	3.909	P 10 (24-1)
1021	18023.839	3.846	R 14 (24-1)
		3.835	R103 (23-0)
1022	18023.581	3.579	P 11 (24-1)
1023	18023.513	3.514	P148 (28-1)
		3.511	R 15 (24-1)
1024	18023.282	3.284	P147 (25-0)

LINE	OBS CM-1	CALC	ASSIGNMENT
1025	18023.225	3.222	P 12 (24-1)
1026	18023.150	3.149	R 16 (24-1)
1027	18022.991	2.991	R130 (24-0)
		2.967	P164 (26-0)
1028	18022.847	2.863	P 78 (25-1)
		2.842	P 59 (22-0)
		2.840	P 13 (24-1)
1029	18022.780	2.762	R 63 (22-0)
		2.762	R 17 (24-1)
1030	18022.441	2.453	R112 (26-1)
		2.433	P 14 (24-1)
1031	18022.349	2.349	R 18 (24-1)
		2.319	R134 (27-1)
1032	18022.111	2.108	R 82 (25-1)
1033	18022.003	1.999	P 15 (24-1)
1034	18021.914	1.911	R 19 (24-1)
1035	18021.749	1.748	P100 (23-0)
1036	18021.541	1.540	P 16 (24-1)
1037	18021.448	1.446	R 20 (24-1)
1038	18021.295	1.292	P 60 (22-0)
1039	18021.225	1.230	R 64 (22-0)
		1.211	R104 (23-0)
		1.167	R151 (25-0)
1040	18021.061	1.093	P131 (27-1)
		1.056	P 17 (24-1)
1041	18020.965	0.994	P109 (26-1)
		0.957	R 21 (24-1)
1042	18020.829	0.828	P127 (24-0)
1043	18020.740	0.737	P 79 (25-1)
1044	18020.547	0.545	P 18 (24-1)
1045	18020.442	0.441	R 22 (24-1)
1046	18019.979	0.010	P 19 (24-1)
		9.969	R 83 (25-1)
	18019.902	9.900	R 23 (24-1)
	18019.822	9.817	R168 (26-0)
1048	18019.719	9.717	P 61 (22-0)
1049	18019.653	9.652	R 65 (22-0)
1050	18019.583	9.580	R131 (24-0)



LINE	OBS CM-1	CALC	ASSIGNMENT
	18020.115		
1046	18019.979	0.010	P 19 (24-1)
		9.969	R 83 (25-1)
1047	18019.902	9.900	R 23 (24-1)
	18019.822	9.817	R168 (26-0)
1048	18019.719	9.717	P 61 (22-0)
1049	18019.653	9.652	R 65 (22-0)
1050	18019.583	9.580	R131 (24-0)
1051	18019.448	9.448	P 20 (24-1)
		9.442	R113 (26-1)
1052	18019.336	9.333	R 24 (24-1)
	18019.229	9.231	P148 (25-0)
		9.218	P149 (25-1)
1053	18019.109	9.107	P101 (23-0)
1054	18018.864	8.861	P 21 (24-1)
1055	18018.743	8.740	R 25 (24-1)
1056	18018.568	8.610	R135 (27-1)
		8.584	P 80 (25-1)
		8.560	R105 (23-0)
	18018.333	8.330	P165 (26-0)
1057	18018.248	8.248	R 22 (24-1)
1058	18018.121	8.122	R 26 (24-1)
		8.116	P 62 (22-0)
1059	18018.051	8.049	R 66 (22-0)
1060	18017.980	7.975	P110 (26-1)
1061	18017.806	7.804	R 84 (25-1)
1062	18017.612	7.609	P 23 (24-1)
1063	18017.481	7.478	R 27 (24-1)
1064	18017.407	7.407	P128 (24-0)
		7.383	P132 (27-1)
	18017.089	7.088	R152 (25-0)
1065	18016.948	6.945	P 24 (24-1)
1066	18016.811	6.809	R 28 (24-1)
1067	18016.493	6.491	P 63 (22-0)
1068	18016.422	6.440	P102 (23-0)
		6.420	R 67 (22-0)
		6.404	P 81 (25-1)
		6.402	R114 (26-1)
1069	18016.258	6.255	P 25 (24-1)
1070	18016.119	6.141	R132 (24-0)
		6.113	R 29 (24-1)
1071	18015.883	5.883	R106 (23-0)
1072	18015.615	5.611	R 85 (25-1)
1073	18015.542	5.539	P 26 (24-1)
1074	18015.394	5.392	R 30 (24-1)
1075	18015.151	5.149	P149 (25-0)
		5.145	R169 (26-0)
1076	18014.930	4.928	P111 (26-1)
1077	18014.842	4.892	P150 (28-1)
		4.871	R136 (27-1)
		4.840	P 64 (22-0)
1078	18014.772	4.798	P 27 (24-1)
		4.767	R 68 (22-0)
1079	18014.648	4.645	R 31 (24-1)
1080	18014.201	4.198	P 82 (25-1)
1081	18014.034	4.031	P 28 (24-1)
1082	18013.960	3.959	P129 (24-0)
1083	18013.875	3.873	R 32 (24-1)
1084	18013.747	3.746	P103 (23-0)
	18013.650	3.663	P166 (26-0)
		3.643	P133 (27-1)
1085	18013.396	3.392	R 86 (25-1)
1086	18013.344	3.335	R115 (26-1)
1087	18013.239	3.238	P 29 (24-1)
1088	18013.171	3.180	R107 (23-0)
		3.164	P 65 (22-0)
1089	18013.085	3.088	R 69 (22-0)
		3.074	R 33 (24-1)
	18012.980	2.980	R153 (25-0)
1090	18012.679	2.675	R133 (24-0)
1091	18012.423	2.420	P 30 (24-1)
1092	18012.253	2.250	R 34 (24-1)
	18012.084		
1093	18011.969	1.965	P 83 (25-1)
1094	18011.856	1.853	P112 (26-1)
1095	18011.579	1.576	P 31 (24-1)
1096	18011.465	1.463	P 66 (22-0)
1097	18011.390	1.401	R 35 (24-1)
		1.384	R 70 (22-0)
1098	18011.149	1.146	R 87 (25-1)
		1.103	R137 (27-1)
1099	18011.029	1.039	P150 (25-0)
		1.027	P104 (23-0)
1100	18010.711	0.706	P 32 (24-1)
1101	18010.528	0.535	P151 (28-1)
		0.525	R 36 (24-1)
1102	18010.455	0.482	P130 (24-0)
		0.450	R108 (23-0)
		0.443	R170 (26-0)
1103	18010.243	0.240	R116 (26-1)
1104	18009.814	9.875	P134 (27-1)
		9.811	P 33 (24-1)
1105	18009.736	9.736	P 67 (22-0)
		9.705	P 84 (25-1)
1106	18009.648	9.654	R 71 (22-0)
		9.624	R 37 (24-1)
1107	18009.184	9.181	R134 (24-0)
	18008.970	8.966	P167 (26-0)
1108	18008.885	8.890	P 34 (24-1)
		8.874	R 88 (25-1)
		8.844	R154 (25-0)
	18008.751	8.750	R113 (26-1)
1109	18008.700	8.697	R 38 (24-1)
1110	18008.281	8.281	P105 (23-0)
1111	18007.986	7.984	P 68 (22-0)
		7.943	P 35 (24-1)
1112	18007.903	7.899	R 72 (22-0)
1113	18007.746	7.744	R 39 (24-1)
1114	18007.697	7.693	R109 (23-0)
1115	18007.420	7.419	P 85 (25-1)
	18007.297	7.305	R138 (27-1)
1116	18007.119	7.116	R117 (26-1)
1117	18006.976	6.979	P131 (24-0)
		6.970	P 36 (24-1)
	18006.903	6.900	P151 (25-0)
1118	18006.767	6.765	R 40 (24-1)
1119	18006.577	6.574	R 89 (25-1)
1120	18006.209	6.207	P 69 (22-0)
1121	18006.120	6.147	P152 (28-1)
		6.119	R 73 (22-0)
		6.077	P135 (27-1)
1122	18005.975	5.972	P 37 (24-1)
1123	18005.764	5.761	R 41 (24-1)
		5.710	R171 (26-0)
1124	18005.657	5.659	R135 (24-0)
		5.620	P114 (26-1)
1125	18005.509	5.508	P106 (23-0)
1126	18005.108	5.105	P 86 (25-1)
1127	18004.916	4.947	P 38 (24-1)
		4.911	R110 (23-0)
1128	18004.732	4.731	R 42 (24-1)
	18004.681	4.678	R155 (25-0)
1129	18004.407	4.405	P 70 (22-0)
1130	18004.313	4.313	R 74 (22-0)
1131	18004.251	4.247	R 90 (25-1)
		4.239	P168 (26-0)
	18003.965	3.964	R118 (26-1)
1132	18003.901	3.897	P 39 (24-1)
1133	18003.678	3.675	R 43 (24-1)
1134	18003.452	3.478	R139 (27-1)
		3.448	P132 (24-0)
1135	18002.824	2.822	P 40 (24-1)
1136	18002.766	2.765	P 87 (25-1)
1137	18002.713	2.732	P152 (25-0)
		2.710	P107 (23-0)
1138	18002.583	2.593	R 44 (24-1)
		2.577	P 71 (22-0)
1139	18002.481	2.482	R 75 (22-0)
		2.461	P115 (26-1)
	18002.250	2.250	P136 (27-1)
1140	18002.106	2.110	R136 (24-0)
		2.101	R111 (23-0)
1141	18001.896	1.894	R 91 (25-1)
1142	18001.724	1.729	P153 (28-1)
		1.720	P 41 (24-1)
1143	18001.489	1.485	R 45 (24-1)
	18000.949	0.947	R172 (26-0)
	18000.785	0.784	R119 (26-1)
1144	18000.726	0.724	P 72 (22-0)
1145	18000.619	0.625	R 76 (22-0)
		0.593	P 42 (24-1)
	18000.485	0.483	R156 (25-0)
	18000.396	0.398	P 88 (25-1)
1146	18000.356	0.352	R 46 (24-1)
	17999.996		
1147	17999.886	9.849	P133 (24-0)
		9.884	P108 (23-0)

Table 2. Interpolation parameters[a] obtained from least squares fits of individual (v'-v") bands to equations (1).

v'-v"	P Branch J_{min}	P Branch J_{max}	P Branch No. Lines Fit	R Branch J_{min}	R Branch J_{max}	R Branch No. Lines Fit	Std. Dev. of Fit (cm^{-1})	$\nu_0 \times 10^{-5}$ (cm^{-1})	$B' \times 10^{1}$ (cm^{-1})	$B'' \times 10^{1}$ (cm^{-1})	$D' \times 10^{7}$ (cm^{-1})	$D'' \times 10^{8}$ (cm^{-1})	$H' \times 10^{13}$ (cm^{-1})	$H'' \times 10^{14}$ (cm^{-1})	$L' \times 10^{18}$ (cm^{-1})
45-0	11	167	73	13	163	77	0.0024	0.195163613	0.18018728	0.37299442	0.277981	0.33354	-1.34323	-3.1957	-1.8958
44-0	22	157	75	7	161	72	0.0022	0.194759905	0.18394367	0.37313127	0.279128	0.46582	-0.88318	0.1893	-1.6130
43-0[b]	27	152	52	10	163	63	0.0027	0.194336823	0.18722787	0.37284063	0.246293	0.22560	-1.12772	-5.4578	-1.8808
42-0	12	175	87	14	174	82	0.0024	0.193894140	0.19094128	0.37308710	0.248824	0.43113	-0.95171	-0.5887	-0.9056
41-0	7	171	81	9	173	94	0.0025	0.193431465	0.19436945	0.37307194	0.233181	0.39122	-1.03320	-1.7714	-0.6655
40-0	8	171	94	6	173	92	0.0022	0.192948559	0.19786561	0.37315117	0.234316	0.46486	-0.57164	-0.1072	-0.9103
39-0	5	171	95	5	169	88	0.0021	0.192445316	0.20116427	0.37311621	0.224764	0.45068	-0.38998	-0.3671	-1.0901
38-0	7	175	84	7	178	90	0.0020	0.191921469	0.20453472	0.37322028	0.224938	0.54155	-0.01774	1.9019	-1.2150
37-0	5	178	90	6	177	100	0.0022	0.191376895	0.20762792	0.37313737	0.201702	0.45137	-0.43993	-0.4603	-0.7966
36-0	4	170	92	5	178	111	0.0023	0.190811385	0.21082957	0.37320255	0.198457	0.54288	-0.37426	1.9948	-0.3438
35-0	5	179	105	5	169	107	0.0021	0.190224898	0.21385144	0.37312974	0.183564	0.48768	-0.56247	0.9779	
34-0	9	176	98	12	179	99	0.0019	0.189617408	0.21683688	0.37306535	0.170785	0.41564	-0.64132	-0.8193	
33-0	13	174	85	14	181	107	0.0025	0.188988936	0.21976994	0.37303719	0.161443	0.39176	-0.65357	-1.5785	
32-0[c]	7	172	71	6	179	88	0.0023	0.188339425	0.22270804	0.37309719	0.156107	0.42573	-0.58491	-0.9737	
31-0[d]	31	172	70	5	178	74	0.0028	0.187668755	0.22521063	0.37275425	0.132334	0.25073	-0.80653	-3.6445	
30-0	11	179	97	7	175	90	0.0015	0.186977046	0.22836349	0.37311068	0.147624	0.45179	-0.39097	-0.1603	
29-0	7	170	101	5	179	112	0.0016	0.186264451	0.23105991	0.37308489	0.138863	0.41706	-0.42877	-1.0541	
28-0	6	173	95	4	175	94	0.0017	0.185530998	0.23372552	0.37309320	0.133996	0.42405	-0.39673	-1.0795	
27-0	5	177	107	5	170	114	0.0024	0.184776805	0.23640338	0.37318390	0.136129	0.51231	-0.17679	1.1841	
26-0	5	171	114	10	172	110	0.0017	0.184001954	0.23892968	0.37316711	0.129675	0.50398	-0.18282	1.1061	
25-0	7	177	119	7	179	111	0.0015	0.183206599	0.24133627	0.37305832	0.119061	0.42247	-0.28070	-0.5431	
24-0	8	168	116	8	174	112	0.0015	0.182391040	0.24375738	0.37304948	0.113625	0.40877	-0.28981	-0.9579	
23-0	17	169	94	5	172	92	0.0017	0.181555307	0.24621734	0.37313994	0.115061	0.46874	-0.16403	0.1433	
22-0[e]	15	164	65	5	170	71	0.0027	0.180699558	0.24864723	0.37324815	0.117127	0.53405	-0.05612	1.2097	
31-1	34	123	17	27	137	20	0.0021	0.185535703	0.22570051	0.37207962	0.159268	0.50413	-0.22472	1.8374	
30-1	9	146	38	12	129	33	0.0020	0.184844042	0.22840061	0.37199561	0.149532	0.45175	-0.34218	-0.6779	
29-1	8	154	38	7	145	44	0.0026	0.184131473	0.23120341	0.37210813	0.152554	0.58087	-0.05690	3.1710	
28-1	12	154	52	8	150	34	0.0023	0.183397930	0.23380043	0.37202312	0.145406	0.55583	-0.01508	3.3062	
27-1	7	163	52	7	156	52	0.0016	0.182643739	0.23631178	0.37191287	0.131330	0.44247	-0.25016	-0.0205	
26-1	6	156	43	7	157	43	0.0012	0.181869034	0.23888172	0.37196383	0.126468	0.45627	-0.25907	-0.1474	
25-1	5	157	57	8	157	69	0.0015	0.181073699	0.24139129	0.37198067	0.123166	0.46501	-0.21543	-0.1149	
24-1	10	167	71	5	161	76	0.0017	0.180258069	0.24382636	0.37198675	0.120973	0.49687	-0.10304	1.1659	
37-2	11	114	21	12	114	25	0.0023	0.187123221	0.20767058	0.37091688	0.216472	0.68350	-0.00006	9.1877	
36-2	8	110	25	11	105	20	0.0026	0.186557601	0.21072968	0.37073115	0.193327	0.37002			
35-2	11	107	21	10	106	20	0.0024	0.185971212	0.21404409	0.37097251	0.202416	0.55783			
34-2	15	109	18	33	108	16	0.0026	0.185363708	0.21686690	0.37075985	0.181556	0.42558			
33-2	24	115	20	40	109	21	0.0024	0.184735201	0.22001681	0.37096045	0.191667	0.62031			

[a] The parameters in this table are to be used only for calculating interpolated line positions in the P and R branches of individual (v'-v") bands, and are presented here with sufficient significant figures to permit this back calculation to within 0.001 cm^{-1}. These parameters are not to be interpreted as molecular constants, and are thus not given with standard deviations, which in all cases correspond to errors considerably greater than implied by the number of significant figures presented in this table.

[b] P and R branches blended from the band origin to P(60) and R(62).

[c] P and R branches blended from the band origin to P(35) and R(38).

[d] P and R branches blended from the band origin to P(92) and R(95).

[e] P and R branches blended from the band origin to P(59) and R(63).

Table 3. Lower state combination differences, $\Delta_2 F''(J)$, for the (v'-0) bands calculated from the constants of Table 2 for J values below that of the last transition used in the least squares fit.

J	(45-0)	(44-0)	(43-0)[a]	(42-0)	(41-0)	(40-0)	(39-0)	(38-0)	(37-0)	(36-0)	(35-0)	(34-0)
10	1.567	1.567	1.566	1.567	1.567	1.567	1.567	1.568	1.567	1.567	1.567	1.567
20	3.058	3.059	3.057	3.059	3.059	3.060	3.059	3.060	3.059	3.060	3.059	3.059
30	4.550	4.551	4.548	4.551	4.551	4.551	4.551	4.552	4.551	4.552	4.551	4.551
40	6.041	6.042	6.039	6.042	6.042	6.043	6.042	6.043	6.042	6.043	6.042	6.041
50	7.531	7.533	7.529	7.532	7.532	7.533	7.532	7.534	7.533	7.533	7.532	7.532
60	9.020	9.022	9.018	9.021	9.021	9.022	9.021	9.023	9.022	9.022	9.021	9.021
70	10.508	10.509	10.507	10.509	10.509	10.510	10.509	10.510	10.510	10.510	10.509	10.509
80	11.995	11.996	11.994	11.995	11.996	11.996	11.995	11.996	11.996	11.995	11.995	11.995
90	13.480	13.480	13.480	13.480	13.481	13.480	13.480	13.480	13.481	13.479	13.479	13.480
100	14.963	14.962	14.963	14.962	14.964	14.963	14.962	14.962	14.963	14.961	14.961	14.963
110	16.444	16.443	16.444	16.443	16.444	16.443	16.442	16.442	16.443	16.441	16.442	16.443
120	17.922	17.920	17.923	17.921	17.922	17.921	17.920	17.919	17.921	17.919	17.920	17.921
130	19.397	19.396	19.397	19.396	19.397	19.395	19.395	19.394	19.395	19.394	19.395	19.396
140	20.867	20.868	20.868	20.868	20.868	20.867	20.867	20.867	20.867	20.867	20.868	20.869
150	22.334	22.337	22.333	22.337	22.336	22.336	22.335	22.338	22.336	22.337	22.339	22.338
160	23.795			23.802	23.799	23.801	23.800	23.806	23.800	23.806	23.806	23.803
170				25.263	25.258	25.263	25.262	25.272	25.261	25.272	25.271	25.264

J	(33-0)	(32-0)[b]	(31-0)[c]	(30-0)	(29-0)	(28-0)	(27-0)	(26-0)	(25-0)	(24-0)	(23-0)	(22-0)[d]
10	1.567	1.567	1.566	1.567	1.567	1.567	1.567	1.567	1.567	1.567	1.567	1.568
20	3.059	3.059	3.056	3.059	3.059	3.059	3.060	3.060	3.059	3.059	3.059	3.060
30	4.550	4.551	4.547	4.551	4.551	4.551	4.552	4.552	4.550	4.550	4.551	4.552
40	6.041	6.042	6.037	6.042	6.042	6.042	6.043	6.043	6.041	6.041	6.042	6.044
50	7.531	7.532	7.527	7.532	7.532	7.532	7.533	7.533	7.531	7.531	7.533	7.534
60	9.020	9.021	9.016	9.021	9.021	9.021	9.022	9.022	9.021	9.021	9.022	9.023
70	10.508	10.509	10.504	10.509	10.509	10.509	10.510	10.509	10.508	10.508	10.509	10.511
80	11.995	11.996	11.991	11.995	11.996	11.996	11.996	11.995	11.995	11.995	11.996	11.997
90	13.480	13.480	13.476	13.480	13.480	13.480	13.480	13.480	13.479	13.480	13.480	13.481
100	14.962	14.963	14.960	14.962	14.963	14.963	14.962	14.962	14.962	14.962	14.962	14.963
110	16.443	16.443	16.442	16.442	16.443	16.443	16.442	16.442	16.443	16.443	16.443	16.442
120	17.921	17.921	17.921	17.920	17.921	17.920	17.919	17.920	17.921	17.921	17.920	17.920
130	19.396	19.396	19.397	19.395	19.396	19.395	19.395	19.395	19.396	19.396	19.395	19.394
140	20.867	20.867	20.869	20.868	20.868	20.867	20.867	20.867	20.869	20.868	20.867	20.866
150	22.335	22.335	22.338	22.337	22.336	22.335	22.337	22.338	22.338	22.337	22.337	22.335
160	23.799	23.800	23.801	23.802	23.801	23.799	23.804	23.805	23.804	23.802	23.802	23.801
170	25.259	25.260	25.259	25.264		25.258	25.269	25.269	25.266			

[a] P and R branches blended from the band origin to P(60) and R(62).

[b] P and R branches blended from the band origin to P(35) and R(38).

[c] P and R branches blended from the band origin to P(92) and R(95).

[d] P and R branches blended from the band origin to P(59) and R(63).

tion to within 0.001 cm^{-1}, even though this requires in all cases many more significant figures than are physically meaningful.

As a consistency check on the rotational assignments in this atlas, which as mentioned above were determined essentially by extending the calculated branches of Wei and Tellinghuisen to higher J, we present in table 3 a set of ground state combination differences. These $\Delta_2 F''(J)$ values were calculated using $v'' = 0$ parameters taken from the band-by-band least squares fits. Since measured I_2 linewidths (FWHM) on the spectral figures are of the order of 0.055 cm^{-1}, we see that calculated interpolated combination differences agree to 1/20 of the FWHM for $J < 150$ and to 1/5 of the FWHM for higher J.

As a further consistency check, Dr. M. M. Hessel [12] has kindly least squares fit 5741 unblended lines assigned in this work to a 29-parameter Dunham expansion, obtaining an overall standard deviation of 0.0042 cm^{-1}. Such a fit introduces only one set of rotational constants for each vibrational level, and furthermore requires these rotational constants to vary smoothly with vibrational quantum number. The Dunham coefficients obtained are close to true molecular constants, but are not given here since the "best" values for such constants must be determined from a fit of the unblended lines from the entire visible spectrum of I_2, rather than from a 1000 cm^{-1} portion.

Unfortunately, no independent support for the vibrational assignments arose from the work for this atlas.

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The NBS Two-Pressure Humidity Generator, Mark 2

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A new humidity calibration facility which uses the two-pressure principle for generating gas of known humidity has been developed at NBS for calibrating and testing hygrometers. The relative humidity range of the two-pressure humidity generator is 3 to 98 percent for ambient temperatures −60 ° to 80 °C and test chamber pressures 5 to 200 kPa (absolute). This is equivalent to a nominal dew/frost point range of −80 ° to 80 °C. Intercomparison tests were made with the NBS standard gravimetric hygrometer over a portion of the generator's operating range. The estimated maximum uncertainty (three standard deviations) is 0.2 percent *RH* for temperatures 0 ° to 80 °C which in units of dew point corresponds to an estimated maximum uncertainty of 0.04 °C for dew points −35 ° to 80 °C.

Key Words: Calibration; dew point; humidity; hygrometer; mixing ratio; relative humidity; two-pressure generator; volume ratio; water vapor.

1. Introduction

The National Bureau of Standards develops, maintains, and disseminates the standards for the humidity measurement system in the United States of America. A gravimetric hygrometer serves as the primary standard [1][1]. Two precision humidity generators [2, 3] are used as the principal facilities for calibrating transfer and secondary standards, and for testing and evaluating hygrometers and sensors. One of these generators [2] has been in use since 1951. It operates on what is now known as the two-pressure principle. A stream of gas at an elevated pressure is saturated with respect to the liquid or solid phase of water and then expanded to a lower pressure. Measurements of the pressure and temperature of the saturated gas stream, and in the test chamber after expansion, yield the data necessary to compute the water vapor content of the gas stream. By selecting and maintaining appropriate temperatures and pressures, it is possible to generate any desired level of humidity in the gas stream. Over the past 25 years this generator has performed with reliability, convenience, and versatility. When the decision was made to replace this old generator with a modern facility, the inherent advantages of the two-pressure principle were the basis for the new design. It seems appropriate, therefore, to call the new generator "The NBS Two-Pressure Humidity Calibration Facility, Mark 2."

Mark 2 produces a continuous stream of gas which can flow at any specified rate up to 0.005 m^3/s—through a test chamber in which the relative humidity can be varied from 3 to 98 percent, the temperature from −60 ° to 80 °C and the absolute pressure from 5 to 200 kPa. It is designed to operate either manually or with digital computer control. This paper describes the operation in the manual mode with the gas stream in the test chamber at approximately 100 kPa.

[1] Figures in brackets indicate the literature references at the end of this paper.

2. General Considerations

The calibration of a hygrometer with the two-pressure humidity generator can be made in various units which relate to the quantity of water vapor in a moist gas. Among the most common units are mixing ratio, dew-point temperature, relative humidity, and volume ratio. These expressions are defined in terms of real gas behavior and account for the fact that the saturation pressure of pure water in the presence of an inert gas differs from that of pure water alone. These units have been defined in general terms by Harrison [4]. Wexler [5] has defined these units explicitly for the two-pressure generator in terms of the measurements of the saturation temperature and pressure (i.e., in the final saturator) and the temperature and pressure in the test chamber or other test space.

The saturation mixing ratio, r_w, of the moist gas emerging from the generator is

$$r_w = \frac{M_w f(P_s, T_s) e_w(T_s)}{M_g[P_s - f(P_s, T_s) e_w(T_s)]} \tag{1}$$

where M_w = molecular weight of water vapor,
M_g = molecular weight of the carrier gas,
$e_w(T_s)$ = saturation vapor pressure over a plane surface of the pure phase of liquid or solid water at the saturator temperature, T_s,
P_s = saturator pressure and
f = enhancement factor and is defined below.

The enhancement factor, f, at the saturator pressure, P_s, and temperature, T_s, is expressed by

$$f(P_s, T_s) = \frac{x_w P_s}{e_w(T_s)} = \frac{(1 - x_g) P_s}{e_w(T_s)} \tag{2}$$

where x_g, x_w = the mole fractions of gas and water vapor in the saturated mixture, respectively.

The definition of the relative humidity RH in the test chamber of the generator is $RH = (x_v/x_w)_{P_c,\,T_c} \times 100$

where x_v = the mole fraction of water vapor in a given sample of moist air characterized by pressure, P_c, and temperature, T_c, and

x_w = the mole fraction of water vapor in the saturated mixture at the same values of pressure, P_c, and temperature, T_c.

Substituting appropriate expressions for the mole fractions yields

$$RH = \frac{f(P_s, T_s)}{f(P_c, T_c)} \times \frac{e_w(T_s)}{e_w(T_c)} \times \frac{P_c}{P_s} \times 100 \qquad (3)$$

where $f(P_c, T_c)$ = enhancement factor at test chamber pressure, P_c, and temperature, T_c,

$e_w(T_c)$ = saturation vapor pressure over a plane surface of the pure phase of liquid or solid water at the test chamber temperature. T_c, and

P_c = test chamber pressure.

The "thermodynamic dew-point (or frost-point) temperature" T_d of a moist gas at absolute total pressure, P, is defined as that temperature at which the moist gas is saturated with respect to a plane surface of pure liquid (or solid) water. The dew point, T_d, of the moist gas of the two-pressure generator is obtained by the iterative solution of

$$f(P_c, T_d)e_w(T_d) = f(P_s, T_s)e_w(T_s)\frac{P_c}{P_s} \qquad (4)$$

where e_w and f are values obtained from suitable tables and P_c is the absolute pressure in any space or volume that is filled with the moist gas, e.g., the mirror chamber of a dew-point hygrometer.

The volume ratio, V, of the moist gas of the two-pressure generator is

$$V = \frac{f(P_s, T_s)e_w(T_s)}{P_s - f(P_s, T_s)e_w(T_s)}\,. \qquad (5)$$

Hence, with the establishment of constant temperatures and pressures in the saturator and test chamber, the various units of humidity can be calculated for the moist gas produced by the two-pressure humidity generator. The formulations[2] of Wexler and Greenspan [6] and Goff [7] are used for obtaining the saturation vapor pressure of water and ice, respectively. When air is used as the carrier gas, the values for the enhancement factor, f, for air, given by Hyland [8], over the temperature range -50 ° to 90 °C and pressures from 0.25×10^5 to 10^7 Pa are used in the above equations. Greenspan [9] has obtained a simplified equation for f which can be easily programmed for a computer or can be calculated with the aid of a programmable pocket calculator.

3. Description

The two-pressure method for generating or producing air of known humidity involves saturating the air or other gas at high pressure with water vapor and then expanding the air to a lower pressure. The generator is designed for a maximum saturator operating pressure of 3.3 MPa which in turn controls the minimum relative humidity. Figure 1 is a simplified flow diagram which illustrates the principle of operation and the basic components.

Compressed air from the house pressure line is first cleaned by using commercially available filters and air driers, D. Alternatively, in the case where a gas other than air is used or air of higher pressure than available from the house air line is required, cylinders of high pressure gas are connected to a manifold and the gas is introduced into the apparatus downstream of the desiccant towers. Two pressure regulators, R_1 and R_2, are used to control the pressure in the humidifying system and a flowmeter, F, is used to monitor the flow rate.

Saturation of the air at high pressure is accomplished in two saturators, S_1 and S_2. Presaturator, S_1, is immersed in a bath, B_1, which is maintained at a temperature of 10 ° to 15 °C warmer than the desired saturation temperature. The presaturator utilizes a centrifugal flow pattern. Air enters the presaturator tangentially to the inner wall and directed slightly downward into the water. A liquid level controller automatically maintains a fixed water level in the presaturator by controlling the solenoid valve, V_1. Supply water is maintained in a container, C, which is at the same pressure as the presaturator. The air enters the presaturator through a coil of 1.27 cm (0.5 in) o.d. tubing and exits at the top of the saturator through a 5.08 cm (2 in) o.d. tubing. Types 316 or 304 stainless steel tubing and fittings are used throughout the system.

The air then passes through the three heat exchangers. H_1, H_2 and H_3, located in the bath, B_2, which is operated at a temperature of 0.5 ° to 1.0 °C warmer than the final saturation temperature. The air which enters the heat exchangers in bath, B_2, is warmer than and also supersaturated with respect to the temperature of bath, B_2. The purpose of bath, B_2, is to make it easier to achieve temperature control in the final bath, B_3, by tempering the air so that it is close to, but still slightly above, the final saturation temperature.

The six radiator type heat exchangers, H_1 through H_6 located in baths, B_2 and B_3, were designed for minimum pressure drop. The air enters the bottom of each heat exchanger which is a horizontal tube 5.08 cm (2 in) o.d. and 0.5 m (18 in) in length. The top of the heat exchanger, which is similar in design and dimensions to the bottom, is connected to the bottom with sixteen parallel tubes 1.9 cm (0.75 in) o.d. and 0.5 m (20.5 in) in length as shown in figure 2.

After the air emerges from the conditioning bath, B_2, it is brought to the final saturation value by flowing through the

[2] In the near future the formulations by Wexler, "Vapor Pressure Formulation for Water in the Range 0 ° to 100 °C. A Revision" and "Vapor Pressure Formulation for Ice," both to be published in the J. Res. Nat. Bur. Stand. (U.S.), will be used. Since Hyland's [8] values for enhancement factor f for air are dependent on the vapor pressure formulation, the enhancement factor will be modified to conform to the new values of the vapor pressure. However, the use of the new values of vapor pressure and enhancement factor will make only very small changes in the final results since the magnitude of the product $f \times e_s$ must remain the same.

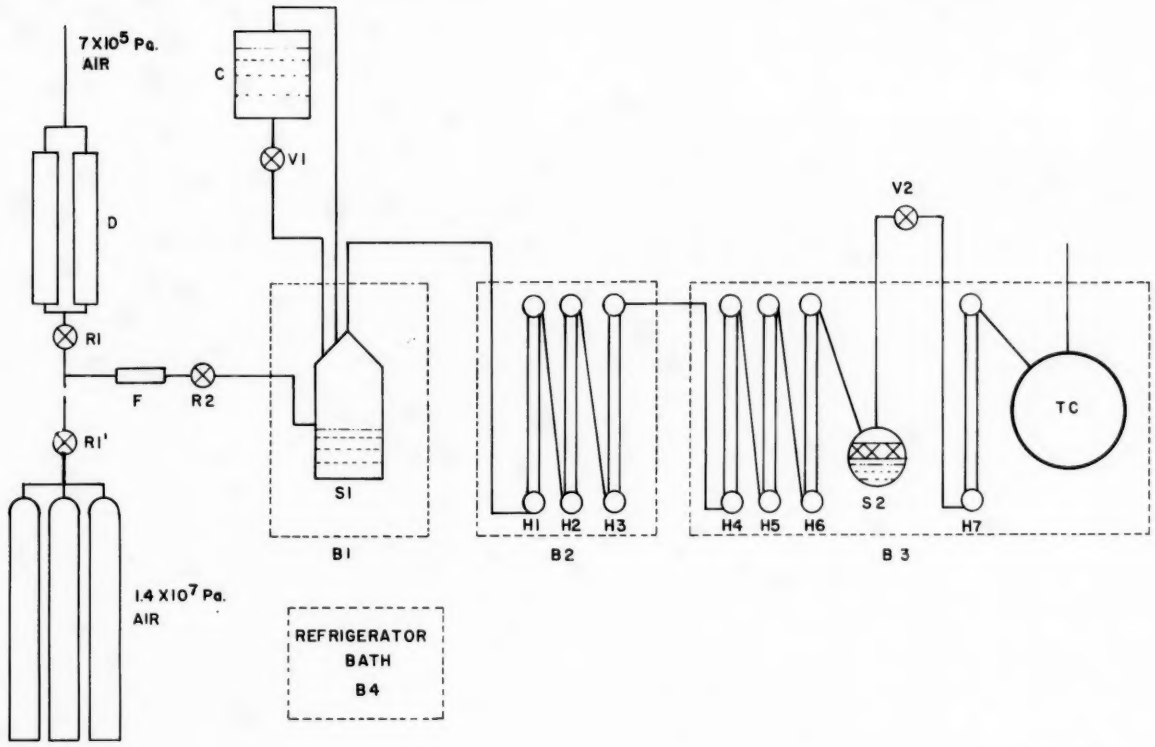

FIGURE 1. *Schematic diagram of two-pressure humidity generator.*

D	Air drier and filters
R1, R2	Pressure regulators
F	Flowmeter
S_1	Presaturator
B_1	Presaturator bath
V_1	Water supply control valve for presaturator
C	Water reservoir for presaturator
B_4	Refrigeration bath for cooling baths B_1, B_2 & B_3
B_2	Conditioning bath
H_1–H_6	Radiator type heat exchanger
B_3	Final bath
S_2	Final saturator
V_2	Digital expansion valve
H_7	Heat exchanger coil
TC	Test chamber

three heat exchangers, H_4–H_6 and the final saturator, S_2, which are located in the bath, B_3. Under the worst operating conditions, i.e., at a flow rate of 0.005 m^3/s and at a pressure of one atmosphere, the maximum pressure drop between the presaturator, S_1, and the outlet of the final saturator, S_2, is 300 Pa. Although the pressure drop in the three heat exchangers in the final bath, B_3, is small, there is still a finite pressure drop and if this pressure drop occurs after the air reaches the final saturation temperature, it will cause the air to be unsaturated. To make up this deficit, a final saturator, S_2, is installed downstream of the heat exchanger, H_6. In addition to resaturating the air, the final saturator provides additional surface area to assure that any water droplets which may be entrained in the air stream precipitate out.

The final saturator, S_2, is a tube having an o.d. of 11.43 cm (4.5 in) with wall thickness of 0.95 cm (0.375 in) and a length of 66.0 cm (26.0 in). The tube is placed in a horizontal position and is half filled with water. A segment from the top of the tube was removed and replaced with a flat plate so that the height of the air space above the water is 2.5 cm. In addition, the air stream is divided into three channels above the water surface and in each channel there is a maze of air deflectors to force the air onto the water surface. In figure 3, which is a photograph of the final saturator, the large tube

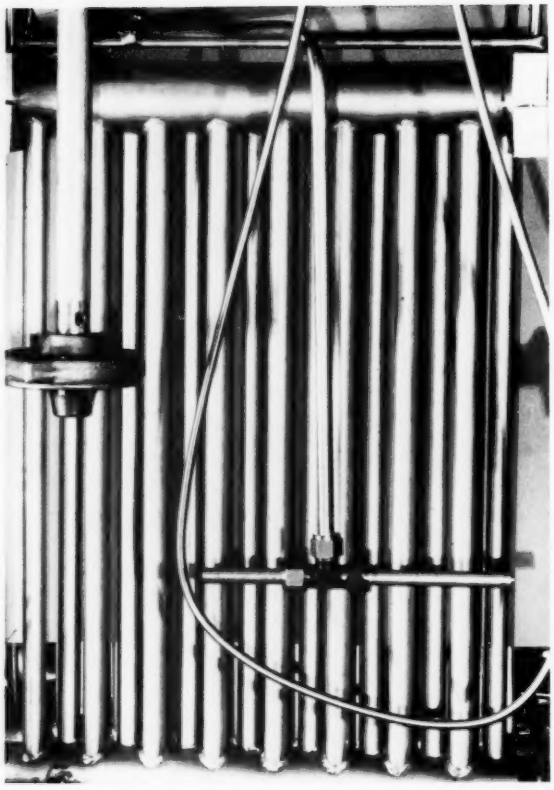

FIGURE 2. *Radiator type heat exchanger*

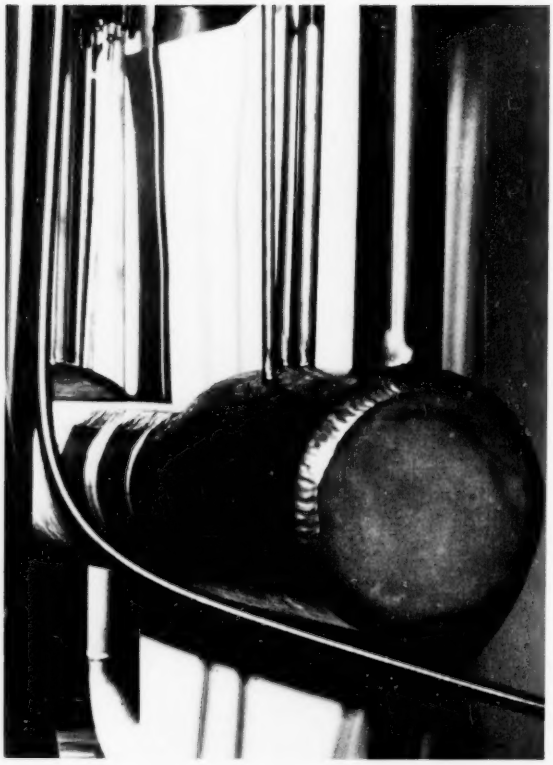

FIGURE 3. *Final Saturator*

located near the end of the saturator is the air outlet tube. The other, smaller tubes provide access for pressure and temperature measurements and also a tap through which the saturated air can be brought from the generator at the saturator pressure, by-passing the expansion valve, V_2, and the test chamber, T_c.

Upon emerging from the final saturator, S_2, the air is expanded to a lower pressure through an expansion valve, V_2, figure 4, which is placed external to the bath, B_3. This valve is thermally insulated and provided with a heater to maintain the valve and plumbing above the dew-point temperature of the adiabatically cooled test gas. The expansion valve is a digital control valve with a 9-bit resolution. It controls ten flow elements (nozzles) whose effective total cross-sectional areas can be chosen over a range of 511 to 1. The effective areas of the flow control elements are arranged in a binary sequence. The valve has a maximum valve coefficient, C_v[3], of 5 and a resolution of approximately 0.2 percent or a C_v of 0.01.

After expansion, the air passes through the heat exchanger, H_7, which is a coil of tubing, 3.8 cm (1.5 in) o.d. and approximately 11 m in length, to bring the air back to the bath temperature before it enters the test chamber, TC, figure 5. The air from the test chamber discharges into the laboratory or into a vacuum source. In the former case, the test chamber will remain at or near atmospheric pressure; in the latter, the test chamber can be controlled at sub-atmospheric pressures through the use of a suitable back-pressure regulator. A length of flexible stainless steel hose between the test chamber and the final heat exchanger permits the test chamber to be taken out of the bath. The test chamber is a cylinder 32.4 cm (12.75 in) o.d., 0.95 cm (0.374 in) wall thickness and 40.6 cm (16 in) in length. Tubular outlets extend from the chamber to allow mechanical controls and electrical leads to be brought in and out of the working space and for measuring the temperature and pressure inside the chamber.

As stated previously the temperature of the final bath, B_3, can be maintained over the range -60 ° to 80 °C. The temperatures of the baths, B_1, B_2, and B_3, are each maintained by balancing a small amount of constant cooling with controlled heating. Cooling is induced by pumping the liquid bath fluid from each bath through its associated heat exchange coils located in the refrigeration bath, B_4, which in turn is cooled with liquid carbon dioxide. The thermocouple indicator and temperature controller for bath, B_4, is an on-off type which controls the opening and closing of a solenoid valve on a liquid carbon dioxide line. The temperature

[3] The value coefficient, C_v, is the number of gallons of water at 60 °F that will pass through the valve per minute with a pressure drop of 1 lb/in^2.

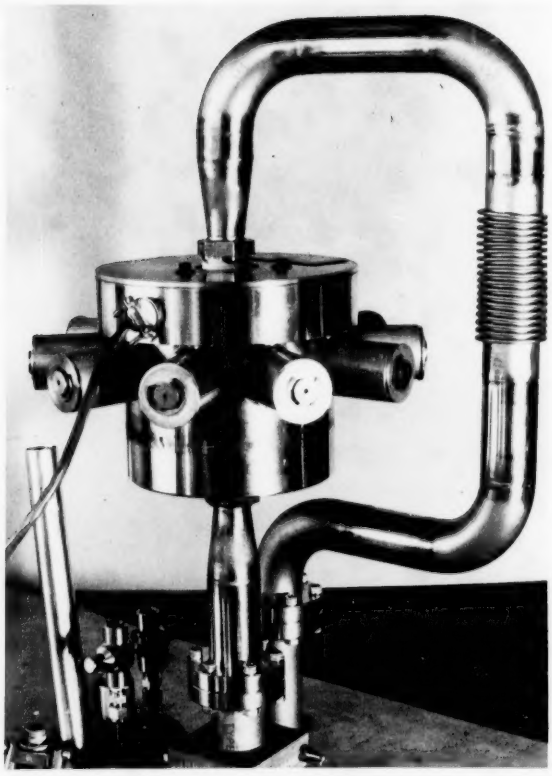

FIGURE 4. *Expansion valve*

controllers for baths, B_1 and B_2, are the power proportional type with resistance thermometer sensor and for bath, B_3, time proportional with reset using a platinum resistance thermometer sensor.

4. Instrumentation

As indicated in eqs 1 through 5, the calculations of the various units of humidity require the measurement of the temperatures and pressures of the final saturator and the test chamber.

To facilitate the automation of data acquisition, the resistances of the calibrated four-lead standard platinum resistance thermometer and the calorimetric type platinum resistance thermometer are measured with a 385 Hz excited bridge based on a design by Cutkosky [10]. The bridge utilizes an inductive ratio divider and requires only one adjustment for balancing. A built-in phase-sensitive null-detector easily resolves 1 $\mu\Omega$ in 25 Ω. Small deviations from balance are recorded continuously with an analog recorder and/or the BCD output of a digital voltmeter is used for recording the data on a teletypewriter at any preselected time interval. The platinum resistance thermometers were calibrated at NBS on the International Practical Temperature Scale of 1968 and subsequently checked from time to time at the triple point of water. It is estimated that the uncertainty in the temperature measurement is an order of magnitude more accurate than the required 10 millidegrees.

The pressures are measured with calibrated fused quartz Bourdon tube pressure gages equipped with BCD outputs. The ranges of the pressure gages used in the generator are 0 to 0.21 MPa (30 psia) for the test chamber and 0 to 0.69 MPa (100 psia) or 0 to 3.3 MPa (500 psig) for the saturator. These gages are periodically calibrated with a dead weight piston

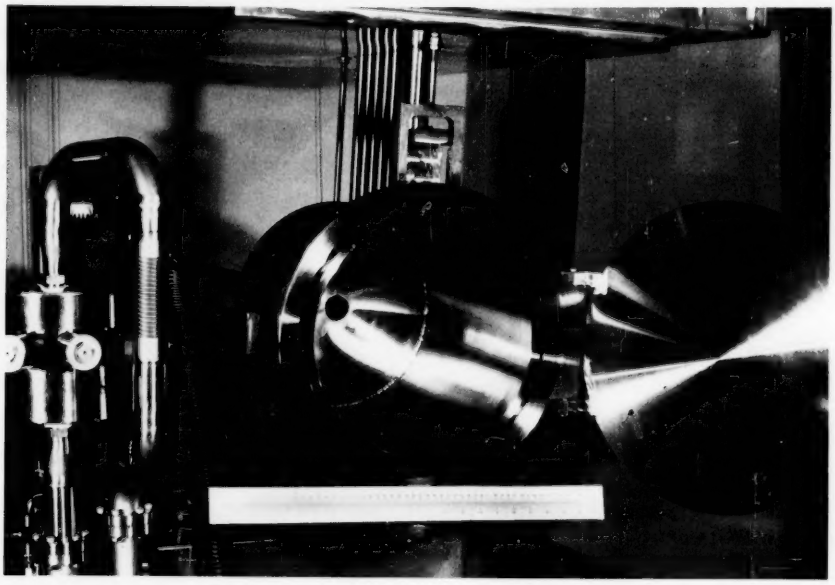

FIGURE 5. *Test chamber*

TABLE 1. *The percentage difference between r_w and r_g*

−0.30% (T_{-20}, Δt_0, P_2, F_{10})	+0.10% (T_0, Δt_5, P_5, F_{10})	+0.10% (T_{25}, Δt_{15}, P_1, F_{10})
+0.17%, −0.32% (T_{-20}, Δt_5, P_1, F_5)	+0.09% (T_0, Δt_{15}, P_2, F_5)	+0.08% (T_{25}, Δt_0, P_5, F_5)
−0.12% (T_{-20}, Δt_{15}, P_5, F_1)	−0.14% (T_0, Δt_0, P_1, F_1)	+0.09%, +0.22% (T_{25}, Δt_5, P_2, F_1)

gage. The accuracy of the pressure measurements is estimated at 70 Pa.

5. Performance

Two independent approaches were used to evaluate the performance of this generator. First, an intercomparison was made between the generator and the NBS gravimetric hygrometer. Second, an analysis was made of all known possible sources of error and from this analysis, an estimate was derived for the accuracy that could be expected from the generator.

5.1. Intercomparison Tests

A 3 × 3 Graeco-latin square experiment [11] was used to test four variable parameters of the two-pressure humidity generator. The experiment was designed to determine whether any of the preselected levels of the parameters could affect the accuracy of the generator. The four parameters which were tested in the experiment were the presaturator temperature, the final saturator temperature, the pressure of the saturator, and the test air flow. Three levels for each of the four parameters were used in the test.

The parameters were arranged in the following form:

T_{-20}, Δt_0, P_2, F_{10}	T_0, Δt_5, P_5, F_{10}	T_{25}, Δt_{15}, P_1, F_{10}
T_{-20}, Δt_5, P_1, F_5	T_0, Δt_{15}, P_2, F_5	T_{25}, Δt_0, P_5, F_5
T_{-20}, Δt_{15}, P_5, F_1	T_0, Δt_0, P_1, F_1	T_{25}, Δt_5, P_2, F_1

where

T = the final saturator temperature and T_{-20} = −20 °C, T_0 = 0 °C, T_{25} = 25 °C;

Δt = the difference in the temperature between the presaturator and the final saturator, the subscript indicating the amount in degrees Celsius that the former exceed the latter;

P = the final saturator pressure and $P_1 = 10^5$ Pa, $P_2 = 2 \times 10^5$ Pa, $P_5 = 5 \times 10^5$ Pa; and

F = the rate of test air flow and F_1 = .03 m³/min, F_5 = .15 m³/min, F_{10} = .3 m³/min (at 25 °C and 10^5 Pa).

Each box of the Graeco-latin square represents a run and the four parameters were maintained at the designated levels. The mixing ratio of the moist air produced by the two-pressure generator was calculated by using eq (1) for each of the runs and the results were compared with the value of the mixing ratio as measured by the NBS standard hygrometer [1]. The NBS standard hygrometer has a maximum uncertainty of 0.12 percent.

a. Results

A percentage difference, d, was obtained by using the eq $d = (r_w - r_g)/r_g \times 100$ where r_w is the computed mixing ratio for the generator and r_g is the mixing ratio measured by the NBS standard hygrometer. The results of the tests for the 3 × 3 Graeco-latin square experiment are given in table 1. Two values in a box represent a repeat run.

In the first column of table 1, T_{-20} is the value of the parameter, T, common to all three boxes in that column while the other three parameters are each represented at the three different levels indicated. Similarly, T_0 and T_{25} are the values of the parameter, T common to all boxes in columns two and three, respectively. If the four tested parameters are assumed to be independent of each other and have no interactions, then the average value in each column is indicative of the correlation of the percentage difference, d, with the value of T for that column. Similar analyses of the rows yield the correlation of d with F, analyses of one set of diagonals give the correlation of d with P, while analyses of the second set of diagonals give the correlation of d with Δt. These results are given in table 2.

TABLE 2. *The correlation of parameter levels with the percentage difference between r_w and r_g*

	d		d		d		d
T_{-20}	0.23%	Δt_{15}	0.10%	P_5	0.10%	F_{10}	0.17%
T_0	0.11%	Δt_5	0.18%	P_2	0.18%	F_5	0.17%
T_{25}	0.12%	Δt_0	0.17%	P_1	0.18%	F_1	0.14%

In order to assess the significance of d in table 2, it is necessary to remember that the maximum uncertainty in r_g is 0.12 percent. Therefore, if d exceeds 0.12 percent, the increase is ascribed to r_w and, more particularly, to the corresponding parameter level.

TABLE 3. *Experimental errors*

Saturator		Estimated systematic errors		3σ-Random errors		$\frac{\Delta e_w}{e_w}$	$\frac{\Delta P_s}{P_s}$	$\frac{\Delta f}{f}$ [a]	Quad [b] $\frac{\Delta r_w}{r_w}\times 100$
Temp.	Press.	Temp.	Press.	Temp.	Press.				
(°C)	(Pa)	(°C)	(Pa)	(°C)	(Pa)				(%)
−20	2×10^5	0.030	69.0	0.00042	41.4	0.00293	0.00055	0.00085	0.31
−20	1×10^5	0.030	69.0	0.00048	47.6	0.00293	0.00117	0.00045	0.32
−20	1×10^5	0.030	69.0	0.00045	18.6	0.00293	0.00088	0.00045	0.31
−20	5×10^5	0.030	69.0	0.00033	24.8	0.00293	0.00019	0.00210	0.36
0	5×10^5	0.010	69.0	0.00012	33.1	0.00073	0.00020	0.00160	0.18
0	2×10^5	0.010	69.0	0.00009	9.0	0.00073	0.00039	0.00065	0.11
0	1×10^5	0.010	69.0	0.00009	16.5	0.00073	0.00086	0.00035	0.12
25	1×10^5	0.010	69.0	0.00033	22.8	0.00060	0.00092	0.00015	0.11
25	5×10^5	0.010	69.0	0.00012	24.8	0.00060	0.00019	0.00088	0.11
25	2×10^5	0.010	69.0	0.00018	8.3	0.00060	0.00039	0.00038	0.08
25	2×10^5	0.010	69.0	0.00042	18.6	0.00060	0.00044	0.00038	0.08

[a] Enhancement factor uncertainties obtained from Hyland's [8] paper.
[b] Combined by quadrature, i.e., the square root of the sum of the squares.

5.2. Error Analysis

An estimate of the maximum uncertainty in the calculated mixing ratio, r_w, of the generator for each of the runs was obtained by using the estimated systematic uncertainty plus three times the random uncertainty of the measured pressure and temperature in the final saturator. The maximum uncertainty of the enhancement factor, which also includes the uncertainty in the saturation vapor pressure values, was obtained from table 9 of Hyland's [8] paper. The standard deviations were computed for the measured temperature and pressure of the saturator in each of the runs and the standard deviation of the mean was used as a measure of the random uncertainty. The systematic uncertainty in the pressure measurement was attributed to the uncertainty in the calibration of the pressure gage, and for the temperature measurement, the systematic uncertainty was primarily due to the maximum temperature gradient detected in the final bath which contains the saturator and the test chamber.

The estimated uncertainty in the calculated mixing ratio was obtained from the expression

$$\frac{\Delta r_w}{r_w}=\frac{P_s}{P_s-fe_w}\left[\left(\frac{\Delta e_w}{e_w}\right)^2+\left(\frac{\Delta P_s}{P_s}\right)^2+\left(\frac{\Delta f}{f}\right)^2\right]^{1/2}. \quad (6)$$

Table 3 lists the estimated systematic uncertainty and the 3σ errors for each of the runs and also the estimated maximum uncertainty of the generator.

By inserting the values of the estimated maximum uncertainty given in table 3 in the appropriate squares of the 3 × 3 Graeco-latin square and by computing the mean for each row, column and diagonal of the square, the results obtained are a measure of the estimated maximum uncertainty of the generator for each level of the tested parameters. These results are given in table 4.

TABLE 4. *The estimated maximum uncertainty of the generator's mixing ratio for the designated levels of the tested parameter*

T_{-20}	0.33%	Δt_{15}	0.19%	P_5	0.22%	F_{10}	0.20%
T_0	0.14%	Δt_5	0.19%	P_2	0.15%	F_5	0.21%
T_{25}	0.10%	Δt_0	0.18%	P_1	0.22%	F_1	0.16%

Comparison of the results (to the nearest tenth of a percent) of tables 2 and 4 show that the calculated maximum uncertainty of the generator is equal to or greater than the percentage difference d for the various levels of the tested parameters and therefore it may be concluded that the performance of the generator is not affected by the four tested parameters over the range which these parameters were tested.

6. Accuracy

The results of the intercomparison tests of the generator with the standard hygrometer which are shown in the previous section indicate that the estimated maximum uncertainty of the generator (based on the systematic and 3σ uncertainties of the temperature and pressure measurements and the maximum error for the enhancement factor) are equal to or greater than the measured difference, d. Therefore, similar calculations were made beyond the range covered by the intercomparison tests to obtain the estimates of the maximum uncertainty for the generator over the temperature range of −55 ° to 80 °C and for pressures from ambient to 3.3×10^6 Pa. Table 5 lists these results which are given in units of mixing ratio, volume ratio, dew-point temperature and relative humidity.

7. Conclusion

The NBS Two-pressure Humidity Calibration Facility, Mark 2 was designed for manual or computer operation and to encompass a humidity range of −80 ° to +80 °C dew points. The generator was also designed to operate over the ambient pressure range of 5000 to 2×10^5 Pa and temperature range of 80 ° to −55 °C.

Intercomparison tests were made with the NBS Standard Hygrometer (gravimetric) over a limited range of the generator. The results of the tests showed that the difference between the humidity calculated for the generator based on measurements of pressure and temperature and the humidity measured by the standard hygrometer were equal to, or less than, the estimated uncertainties based on the estimates of the maximum contributions to the systematic uncertainty plus

TABLE 5. *NBS two-pressure humidity generator, mark 2, range and accuracy*

Humidity parameter	Range	Accuracy[a]
Mixing ratio, r_w (g water vapor/kg dry air)	$0.0005 \leq r_w < 0.0015$	3.0% of value
	$0.0015 \leq r_w < 0.005$	1.5% of value
	$0.005 \leq r_w < 0.1$	1.0% of value
	$0.1 \leq r_w < 0.3$	0.5% of value
	$0.3 \leq r_w < 515$	0.3% of value
Volume ratio, V (ppm)	$1 \leq V < 3$	3.0% of value
	$3 \leq V < 10$	1.5% of value
	$10 \leq V < 170$	1.0% of value
	$170 \leq V < 500$	0.5% of value
	$500 \leq V < 820{,}000$	0.3% of value
Dew-point temperature, T_d °C	$-80 \leq T_d < -70$	0.2
	$-70 \leq T_d < -35$	0.1
	$-35 \leq T_d < +80$	0.04
Relative humidity, *RH* (%) at test chamber temperature T_c (°C) of:		
$-55 \leq T_c < -40$	3–98	1.5
$-40 \leq T_c < -20$	3–98	0.8
$-20 \leq T_c < 0$	3–98	0.4
$0 \leq T_c < +80$	3–98	0.2

[a] The estimated bounds to systematic error plus three times the standard deviation.

three times the standard deviation for the parameters of the pressure, temperature and enhancement factor. The estimates of the maximum uncertainty of the generator are listed in table 5. The magnitude of the uncertainties for the new generator is at least 50 percent less than current estimated uncertainties used for humidity at the National Bureau of Standards [3].

Work is still in progress on the development of an interface between the generator and a minicomputer and on testing the generator for subatmospheric pressure operation. It is also planned to extend the intercomparison tests with the standard hygrometer at both higher and lower humidities.

We wish to express our gratitude to R. W. Hyland for the operation of the NBS Standard Hygrometer, to the members of the NBS Shop Division and in particular to W. Koepper (now retired) and to B. Beuchert for the fabrication of the generator, and to L. Marzetta for building the a.c. thermometer bridge.

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Humidity Fixed Points of Binary Saturated Aqueous Solutions

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An evaluated compilation of equilibrium relative humidities in air versus temperature from pure phase to approximately 10^5 pascal (1 atm) in pressure is presented for 28 binary saturated aqueous solutions. The relative humidities of the solutions range from about 3 to 98 percent. Using a data base from 21 separate investigations comprising 1106 individual measurements, fits were made by the method of least squares to regular polynomial equations with two through four coefficients. Equations and tables are presented along with the estimated uncertainties in the correlated results.

Key words: aqueous solution; equilibrium; humidity; relative humidity; salt; saturated salt solution; vapor pressure; water vapor.

1. Introduction

Research, hygrometer calibration, testing and material conditioning often require the accurate control of humidity in a working space. The common methods of controlling the humidity accurately use either a humidity generator [1A][1] or the equilibration of a closed space with a chemical system [1B] which produces the desired equilibrium vapor pressure.

Humidity generators tend to be expensive and complex whereas equilibration with chemical systems that provide fixed points is a relatively inexpensive and simple method of humidity control. Among the chemical systems used for this purpose are aqueous sulphuric acid solutions, glycerine and water solutions and single and binary salt solutions. Each such solution offers a degree of humidity adjustment that can be achieved by changing its concentration. On the other hand, special problems are associated with the use of solutions because their concentrations must be measured and controlled. Not only must the concentration of the solution be determined initially but the presence of any humidity sources or sinks in the controlled space and even the initial equilibration process of the space can alter the solution concentration.

An especially useful method of humidity control by chemical system involves the use of binary saturated aqueous solutions (primarily of single salts) in which the solute is highly non-volatile.

At any temperature, the concentration of a saturated solution is fixed and does not have to be determined. By providing excess solute, the solution will remain saturated even in the presence of modest sources or sinks. Where the solute is a solid in the pure phase, it is easy to determine that there is indeed saturation. Due to the ease of its use, this is a popular method of humidity control.

Since a given saturated salt solution provides only one relative humidity (RH) at any desired temperature, a different relative humidity must be achieved by selecting another appropriate salt. Though much data on saturated salt solutions have been produced and many compilations of the equilibrium relative humidities of selected saturated salt solutions exist, there are no compilations for which the data have been critically analyzed and estimates of the uncertainties involved given, a step which is abolutely essential to the implimentation of the concept of fixed points.

We have moved to fill this gap by compiling, from the literature, data on a sufficient variety of saturated salt solutions to cover the entire range of relative humidity at reasonably close intervals. We have adjusted these data [1–21] to be consistent with temperatures on IPTS-68 and the most recent equations for the vapor pressure of water [22]. We have also analyzed the experimental techniques used in obtaining the original data and have made estimates of the uncertainties in the original data. We have then used these data to calculate "best" values of relative humidity in air as a function of temperature from pure phase to approximately 10^5 pascal (1 atm) in pressure for these saturated solutions.

2. Background

The methods used by investigators to determine the water vapor in equilibrium with saturated salt solutions are diverse. A short description of the various methods used in the referenced papers is of interest.

(1) *The direct measurement of the vapor pressure.* A chamber containing a saturated salt solution at a controlled temperature is first evacuated to remove all gases. Evaporation from the solution is then allowed to proceed until the ambient vapor, essentially all water, has come to equilibrium with the solution and a direct determination of the total pressure within the chamber is made by conventional pressure measurement techniques.

(2) *Dew point measurement.* The dew point of the gas within a chamber containing a saturated salt solution at controlled temperature is measured by means of a cooled mirror within the chamber. Using vapor pressure tables or equations, this dew point is converted to the vapor pressure of water.

(3) *Isopiestic vapor pressure measurement.* The vapor pres-

[1] Figures in brackets indicate the literature references at the end of this paper.

sure of a saturated salt solution in one cell or chamber is allowed to come to equilibrium with a cell or chamber containing a reference solution at a fixed temperature. The reference solution must be well characterized as to vapor pressure as a function of concentration at the reference temperature. Under the equilibrium condition, the equilibrium vapor pressure of the saturated salt solution is identical to the equilibrium vapor pressure of the reference solution. After the two cells have reached equilibrium, the concentration of the reference solution is determined (usually by weighing) and the vapor pressure is calculated.

(4) *Relative vapor pressure measurement*. A chamber containing a saturated salt solution and a chamber containing pure water or other well characterized solution are each evacuated to remove all non-water vapor gases. The two chambers are maintained at the same temperature and the absolute pressure of the saturated salt solution is measured as in the first method. In addition the pressure difference between the two chambers and/or the pressure of the reference solution is determined. The ratio of the vapor pressure of the saturated salt solution to the vapor pressure of the water is the activity (or relative humidity) of the saturated salt solution.

(5) *Measurement with a calibrated humidity sensor*. A chamber containing a saturated salt solution and a humidity sensor are brought to equilibrium at a controlled temperature. Calibration of the sensor before or/and after the measurement provides the means of determining the equilibrium vapor pressure.

(6) *Gravimetric determination*. Dry gas is passed through the binary saturated solution at a fixed temperature. The water vapor in the effluent gas is absorbed by a desiccant and measured by weighing. The volume of the gas is also determined. From these the vapor pressure or the mixing ratio can be determined.

As one would imagine, the errors associated with these methods differ as to source and magnitude. The errors in any of the methods are also functions of the level of vapor pressure being measured as well as the temperature of the saturated salt solution. There is, therefore, probably no one method that gives a best measurement under all conditions.

3. Method

We have accumulated experimental data from various researchers [1–21] and calculated "best" values of relative humidity and the associated uncertainties of those values. Typical methods of calculating or recalculating the relative humidity and associated uncertainties for the various investigations are given in the Appendix. Our data base consists of 21 investigations and includes some of the most cited work in the field. In total, 1106 individual calculations of relative humidities and associated uncertainties were made which involved 89 saturated solutions. Not all data nor all saturated solutions in this study were found satisfactory for use.

The original data were corrected to be consistent with temperature on IPTS-68, with the most recent formulation for the vapor pressure of water [22] and with the most recent equations for the enhancement of water vapor in air [23]. The computed relative humidity data were then collated and fitted by the method of least squares to regular polynomials as a function of temperature in degrees Celsius (IPTS-68). In the fitting process, each datum was weighted inversely proportional to the estimated uncertainty of the datum. The order of the polynomial used in the fit was determined by an F-test or by analysis of the result of fits to various orders. An arbitrary decision was made not to use any order higher than 3. Also, no data at temperatures below 0 °C or above 104 °C were used in the fits.

In the fitting process, the standard deviation of the predicted value was computed for each datum. These standard deviations were themselves fitted to a quadratic equation, as a function of temperature, by the method of least squares. At any desired temperature for a given saturated salt solution, the standard deviation of the predicted value was calculated using the appropriate quadratic equation. Three times this value was then assigned as the estimated uncertainty for the corresponding value of relative humidity, with certain exceptions discussed below. This is the value which appears in table 2.

Where a number of investigations of the same solution existed and the relative humidity vs temperature results of one investigation were completely inconsistent with the results of the other investigations, the data of the deviant investigation were eliminated and a new fit made.

The data used in this paper met one of the following criteria: (1) a large number of investigations were included and exhibited a small residual standard deviation of the relative humidity vs temperature fits; (2) although few investigations were included, the method of measurement was judged to be superior and estimates of the uncertainties of the original measurements themselves were small; and (3) the data were in a relative humidity range which was not approximated by any of the other binary saturated solutions.

4. Results

Table 1 contains coefficients for the data of the selected salts fitted to an equation of the form:

$$RH = \sum_{i=0}^{3} A_i t^i$$

where RH is in percent and t is in °C (IPTS–68). The salts are listed in ascending order of RH at 25 °C. Also included in table 1 is the residual standard deviation of the fit, the range of temperature over which the fit was performed and references for the fundamental data that were involved in that particular fit.

Table 2 gives the calculated relative humidities for each of the binary saturated solutions at 5-degree intervals along with the estimated uncertainties in relative humidity at each of the temperatures. The saturated salt solutions are presented in the same order as in table 1.

5. Discussion

Although the method used for fitting the data gave no problems, the assignment of weights to each datum required some judgment. Three methods of weighting were considered: (1) weights were assigned inversely proportional to the variance of the individual datum where the variance was taken as the square of the total uncertainty; (2) weights were assigned inversely proportional to the estimated total uncertainty of the individual datum; and (3) weights of unity were assigned to all data.

All of the data were fitted three times, once for each type of weighting. The results were assembled into three tables of

TABLE 1. *Summary of Least Squares Fits to* $RH = \sum_{i=0}^{3} A_i t^i$ *for Selected Saturated Salt Solutions*

Salt	A_0	A_1	A_2	A_3	σ	No. of Points	t_{min}	t_{max}	Data Source (a)
Cesium Fluoride	6.20938	−0.143381	0.123037×10^{-2}		0.54	21	5.0	80.0	2, 17
Lithium Bromide	7.75437	−0.0654994	0.420737×10^{-3}		.22	21	0.0	100.0	2, 14
Zinc Bromide	9.28455	−0.0906508	0.118143×10^{-2}		.20	16	5.0	70.0	2, 14
Potassium Hydroxide	16.7049	−0.511352	0.796712×10^{-2}	-0.426364×10^{-4}	.28	14	5.0	70.0	2
Sodium Hydroxide	11.5581	−0.132339			.90	24	15.0	75.0	1, 16
Lithium Chloride	11.2323	−0.00824245	-0.214890×10^{-3}		.67	100	0.0	100.3	1, 3, 10, 11, 17, 18, 20
Calcium Bromide	23.5670	−0.136117	-0.585836×10^{-2}		.06	7	11.2	25.0	11, 14
Lithium Iodide	22.8216	−0.232642	0.132306×10^{-2}	-0.168738×10^{-4}	.05	15	5.0	70.0	2, 14
Potassium Acetate	22.4388	0.156288	0.612868×10^{-2}		.22	10	11.2	31.0	11, 14, 17
Potassium Fluoride	65.7907	−2.07303	0.305676×10^{-1}		.36	8	25.0	90.0	6, 14
Magnesium Chloride	33.6686	−0.00797397	-0.108988×10^{-2}		.28	48	0.00	99.4	1, 7, 11, 14, 17, 19, 21
Sodium Iodide	42.6040	0.00854045	-0.933320×10^{-2}	0.761055×10^{-4}	.50	25	5.0	90.0	1, 6, 11, 14
Potassium Carbonate	43.1315	0.00147523			.31	9	0.0	30.0	8, 14, 17
Magnesium Nitrate	60.3514	−0.298153			.34	24	0.0	48.1	1, 8, 17, 19, 21
Sodium Bromide	64.7190	−0.221990	-0.402414×10^{-2}	0.0590331×10^{-4}	.44	22	5.0	80.0	2, 6, 11, 17
Cobalt Chloride	73.0330	0.0852795	-0.218455×10^{-1}	$0.218691 \times 10^{-}$	1.44	17	23.4	78.9	6
Potassium Iodide	74.5466	−0.253167	0.104383×10^{-2}		0.20	12	5.0	90.0	1, 6
Strontium Chloride	78.5322	−0.273114	-0.135136×10^{-2}		.02	7	5.0	30.0	1, 17
Sodium Nitrate	79.5738	−0.193192	-0.122102×10^{-2}	0.174308×10^{-4}	.37	25	5.0	90.0	1, 6, 9, 17
Sodium Chloride	75.5164	0.0398321	-0.265459×10^{-2}	0.284800×10^{-4}	.21	44	0.0	80.0	1, 6, 8, 11, 12, 13, 15, 17, 19, 21
Ammonium Chloride	81.8777	−0.132271			.60	20	11.2	31.0	9, 11
Potassium Bromide	86.6424	−0.332271	0.459734×10^{-2}	-0.199429×10^{-4}	.14	11	5.0	80.0	1, 6, 17
Ammonium Sulfate	81.7794	−0.0715320			.40	21	0.4	48.0	9, 18, 20
Potassium Chloride	88.6190	−0.193340	0.899706×10^{-3}		.45	39	0.0	90.0	1, 6, 8, 9, 12, 17
Strontium Nitrate	94.2127	−0.366025			.19	5	5.0	25.0	1
Potassium Nitrate	96.3361	0.0112371	-0.484514×10^{-2}		.80	22	0.6	48.1	9, 17, 19, 21
Potassium Sulfate	98.7792	−0.0590502			.47	18	0.5	52.3	12, 19, 21
Potassium Chromate	103.934	−0.310163	0.273023×10^{-2}		.22	7	23.7	50.8	12, 17

(a) Numbers correspond to references.

TABLE 2. *Equilibrium Relative Humidity of Selected Saturated Salt Solutions from 0 to 100 °C*

T °C	Relative Humidity, %									
	Cesium Fluoride	Lithium Bromide	Zinc Bromide	Potassium Hydroxide	Sodium Hydroxide	Lithium Chloride	Calcium Bromide	Lithium Iodide	Potassium Acetate	Potassium Fluoride
0		7.75 ± 0.83				11.23 ± 0.54				
5	5.52 ± 1.9	7.43 ± 0.76	8.86 ± 0.89	14.34 ± 1.7		11.26 ± 0.47		21.68 ± 0.30		
10	4.89 ± 1.6	7.14 ± 0.69	8.49 ± 0.74	12.34 ± 1.4		11.29 ± 0.41	21.62 ± 0.50	20.61 ± 0.25	23.38 ± 0.53	
15	4.33 ± 1.4	6.86 ± 0.63	8.19 ± 0.61	10.68 ± 1.1	9.57 ± 2.8	11.30 ± 0.35	20.20 ± 0.50	19.57 ± 0.20	23.40 ± 0.32	
20	3.83 ± 1.1	6.61 ± 0.58	7.94 ± 0.49	9.32 ± 0.90	8.91 ± 2.4	11.31 ± 0.31	18.50 ± 0.50	18.56 ± 0.16	23.11 ± 0.25	
25	3.39 ± 0.94	6.37 ± 0.52	7.75 ± 0.39	8.23 ± 0.72	8.24 ± 2.1	11.30 ± 0.27	16.50 ± 0.20	17.56 ± 0.13	22.51 ± 0.32	30.85 ± 1.3
30	3.01 ± 0.77	6.16 ± 0.47	7.62 ± 0.31	7.38 ± 0.56	7.58 ± 1.7	11.28 ± 0.24		16.57 ± 0.10	21.61 ± 0.53	27.27 ± 1.1
35	2.69 ± 0.63	5.97 ± 0.43	7.55 ± 0.25	6.73 ± 0.44	6.92 ± 1.5	11.25 ± 0.22		15.57 ± 0.08		24.59 ± 0.94
40	2.44 ± 0.52	5.80 ± 0.39	7.54 ± 0.20	6.26 ± 0.35	6.26 ± 1.2	11.21 ± 0.21		14.55 ± 0.06		22.68 ± 0.81
45	2.24 ± 0.44	5.65 ± 0.35	7.59 ± 0.17	5.94 ± 0.29	5.60 ± 1.0	11.16 ± 0.21		13.49 ± 0.05		21.46 ± 0.70
50	2.11 ± 0.40	5.53 ± 0.31	7.70 ± 0.16	5.72 ± 0.27	4.94 ± 0.85	11.10 ± 0.22		12.38 ± 0.05		20.80 ± 0.62
55	2.04 ± 0.38	5.42 ± 0.28	7.87 ± 0.17	5.58 ± 0.28	4.27 ± 0.73	11.03 ± 0.23		11.22 ± 0.05		20.60 ± 0.56
60	2.03 ± 0.40	5.33 ± 0.25	8.09 ± 0.19	5.49 ± 0.32	3.61 ± 0.65	10.95 ± 0.26		9.98 ± 0.06		20.77 ± 0.53
65	2.08 ± 0.44	5.27 ± 0.23	8.38 ± 0.24	5.41 ± 0.39	2.95 ± 0.60	10.86 ± 0.29		8.65 ± 0.07		21.18 ± 0.53
70	2.20 ± 0.52	5.23 ± 0.21	8.72 ± 0.30	5.32 ± 0.50	2.29 ± 0.60	10.75 ± 0.33		7.23 ± 0.09		21.74 ± 0.56
75	2.37 ± 0.62	5.20 ± 0.19			1.63 ± 0.64	10.64 ± 0.38				22.33 ± 0.61
80	2.61 ± 0.76	5.20 ± 0.18				10.51 ± 0.44				22.85 ± 0.69
85		5.22 ± 0.17				10.38 ± 0.51				23.20 ± 0.80
90		5.26 ± 0.17				10.23 ± 0.59				23.27 ± 0.93
95		5.32 ± 0.16				10.07 ± 0.67				
100		5.41 ± 0.17				9.90 ± 0.77				

TABLE 2. *Equilibrium Relative Humidity of Selected Saturated Salt Solutions from 0 to 100 °C—Continued*

T °C	Relative Humidity, %									
	Magnesium Chloride	Sodium Iodide	Potassium Carbonate	Magnesium Nitrate	Sodium Bromide	Cobalt Chloride	Potassium Iodide	Strontium Chloride	Sodium Nitrate	Sodium Chloride
0	33.66 ± 0.33		43.13 ± 0.66	60.35 ± 0.55						75.51 ± 0.34
5	33.60 ± 0.28	42.42 ± 0.99	43.13 ± 0.50	58.86 ± 0.43	63.51 ± 0.72		73.30 ± 0.34	77.13 ± 0.12	78.57 ± 0.52	75.65 ± 0.27
10	33.47 ± 0.24	41.83 ± 0.83	43.14 ± 0.39	57.36 ± 0.33	62.15 ± 0.60		72.11 ± 0.31	75.66 ± 0.09	77.53 ± 0.45	75.67 ± 0.22
15	33.30 ± 0.21	40.88 ± 0.70	43.15 ± 0.33	55.87 ± 0.27	60.68 ± 0.51		70.98 ± 0.28	74.13 ± 0.06	76.46 ± 0.39	75.61 ± 0.18
20	33.07 ± 0.18	39.65 ± 0.59	43.16 ± 0.33	54.38 ± 0.23	59.14 ± 0.44		69.90 ± 0.26	72.52 ± 0.05	75.36 ± 0.35	75.47 ± 0.14
25	32.78 ± 0.16	38.17 ± 0.50	43.16 ± 0.39	52.89 ± 0.22	57.57 ± 0.40	64.92 ± 3.5	68.86 ± 0.24	70.85 ± 0.04	74.25 ± 0.32	75.29 ± 0.12
30	32.44 ± 0.14	36.15 ± 0.43	43.17 ± 0.50	51.40 ± 0.24	56.03 ± 0.38	61.83 ± 2.8	67.89 ± 0.23	69.12 ± 0.03	73.14 ± 0.31	75.09 ± 0.11
35	32.05 ± 0.13	34.73 ± 0.39		49.91 ± 0.29	54.55 ± 0.38	58.63 ± 2.2	66.96 ± 0.23		72.06 ± 0.32	74.87 ± 0.12
40	31.60 ± 0.13	32.88 ± 0.37		48.42 ± 0.37	53.17 ± 0.41	55.48 ± 1.8	66.09 ± 0.23		71.00 ± 0.34	74.68 ± 0.13
45	31.10 ± 0.13	31.02 ± 0.37		46.93 ± 0.47	51.95 ± 0.47	52.56 ± 1.5	65.26 ± 0.24		69.99 ± 0.37	74.52 ± 0.16
50	30.54 ± 0.14	29.21 ± 0.40		45.44 ± 0.60	50.93 ± 0.55	50.01 ± 1.4	64.49 ± 0.26		69.04 ± 0.42	74.43 ± 0.19
55	29.93 ± 0.16	27.50 ± 0.45			50.15 ± 0.65	48.02 ± 1.4	63.78 ± 0.28		68.15 ± 0.49	74.41 ± 0.24
60	29.26 ± 0.18	25.95 ± 0.52			49.66 ± 0.78	46.74 ± 1.5	63.11 ± 0.31		67.35 ± 0.57	74.50 ± 0.30
65	28.54 ± 0.21	24.62 ± 0.62			49.49 ± 0.94	46.33 ± 1.9	62.50 ± 0.34		66.64 ± 0.67	74.71 ± 0.37
70	27.77 ± 0.25	23.57 ± 0.74			49.70 ± 1.1	46.97 ± 2.3	61.93 ± 0.38		66.04 ± 0.78	75.06 ± 0.45
75	26.94 ± 0.29	22.85 ± 0.88			50.33 ± 1.3	48.80 ± 2.9	61.43 ± 0.43		65.56 ± 0.91	75.58 ± 0.55
80	26.05 ± 0.34	22.52 ± 1.0			51.43 ± 1.5	52.01 ± 3.7	60.97 ± 0.48		65.22 ± 1.1	76.29 ± 0.65
85	25.11 ± 0.39	22.63 ± 1.2					60.56 ± 0.54		65.03 ± 1.2	
90	24.12 ± 0.46	23.25 ± 1.4					60.21 ± 0.61		65.00 ± 1.4	
95	23.07 ± 0.52									
100	21.97 ± 0.60									

TABLE 2. *Equilibrium Relative Humidity of Selected Saturated Salt Solutions from 0 to 100 °C – Continued*

T °C	Relative Humidity, %							
	Ammonium Chloride	Potassium Bromide	Ammonium Sulfate	Potassium Chloride	Strontium Nitrate	Potassium Nitrate	Potassium Sulfate	Potassium Chromate
0			82.27 ± 0.90	88.61 ± 0.53		96.33 ± 2.9	98.77 ± 1.1	
5		85.09 ± 0.26	82.42 ± 0.68	87.67 ± 0.45	92.38 ± 0.56	96.27 ± 2.1	98.48 ± 0.91	
10	80.55 ± 0.96	83.75 ± 0.24	82.06 ± 0.51	86.77 ± 0.39	90.55 ± 0.38	95.96 ± 1.4	98.18 ± 0.76	
15	79.89 ± 0.59	82.62 ± 0.22	81.70 ± 0.38	85.92 ± 0.33	88.72 ± 0.28	95.41 ± 0.96	97.89 ± 0.63	
20	79.23 ± 0.44	81.67 ± 0.21	81.34 ± 0.31	85.11 ± 0.29	86.89 ± 0.29	94.62 ± 0.66	97.59 ± 0.53	
25	78.57 ± 0.40	80.89 ± 0.21	80.99 ± 0.28	84.34 ± 0.26	85.06 ± 0.38	93.58 ± 0.55	97.30 ± 0.45	97.88 ± 0.49
30	77.90 ± 0.57	80.27 ± 0.21	80.63 ± 0.30	83.62 ± 0.25		92.31 ± 0.60	97.00 ± 0.40	97.08 ± 0.41
35		79.78 ± 0.22	80.27 ± 0.37	82.95 ± 0.25		90.79 ± 0.83	96.71 ± 0.38	96.42 ± 0.37
40		79.43 ± 0.24	79.91 ± 0.49	82.32 ± 0.25		89.03 ± 1.2	96.41 ± 0.38	95.89 ± 0.37
45		79.18 ± 0.26	79.56 ± 0.65	81.74 ± 0.28		87.03 ± 1.8	96.12 ± 0.40	95.50 ± 0.40
50		79.02 ± 0.28	79.20 ± 0.87	81.20 ± 0.31		84.78 ± 2.5	95.82 ± 0.45	95.25 ± 0.48
55		78.95 ± 0.32		80.70 ± 0.35				
60		78.94 ± 0.35		80.25 ± 0.41				
65		78.99 ± 0.40		79.85 ± 0.48				
70		79.07 ± 0.45		79.49 ± 0.57				
75		79.16 ± 0.50		79.17 ± 0.66				
80		79.27 ± 0.57		78.90 ± 0.77				
85				78.68 ± 0.89				
90				78.50 ± 1.0				
95								
100								

relative humidity at 5-degree intervals. Each calculated value of relative humidity was assigned an uncertainty equal to three times the standard deviation of the predicted value. As might be expected, the calculated relative humidities and the corresponding uncertainties differed for each of the three weightings. For the saturated solutions chosen for presentation in this paper, it was noted with some satisfaction that all relative humidities calculated from the three differently weighted fits agreed with each other to within the assigned uncertainty for each.

A weighting inversely proportional to the square of the estimated total uncertainty for each datum was judged to be inappropriate. Although it is common to assign weights proportional to the inverse of sigma squared such an approach is usually based on a sigma which is statistically determined. This is not the case here. The method used to obtain the estimated total uncertainty is given in the Appendix. It was felt that the use of the square of the estimated uncertainty would have placed an unacceptably high value on the author's estimate of the errors contributing to the total uncertainty. Some investigators did not provide sufficient information in their publications to make possible completely objective estimates of their errors. In those cases, the estimated total uncertainty included components based on the author's subjective judgments.

A weighting of unity was likewise unsatisfactory since it would in no way take into account the innate difference in uncertainty due to method, temperature and relative humidity range, nor would it place any reliance on the author's judgment of the quality of the research. A weighting proportional to the inverse of the estimated uncertainty appeared to be a reasonable compromise between the other extremes and all data presented in this publication were processed using that weighting method.

Where the data for a particular saturated salt solution included a number of investigations, three times the standard deviations of the computed values were accepted as the estimated uncertainty. Where the data were based only on one or two investigations it is evident that self consistent data, though quite inaccurate, could give small estimated standard deviations of the computed values. It is also evident that such standard deviations are not a valid estimate of uncertainty. Under those circumstances where the results from fitting the polynomial equation to the original data for any saturated salt solution gave values for three times the standard deviation of the predicted value that were less than the *estimated* total uncertainty of the original data, it was the estimated total uncertainty of the original data which was used as the final estimate of uncertainty for the calculated "best" value of relative humidity.

The data presented in table 2 are given at 5 °C intervals over the temperature range of the original data with extrapolations beyond these ranges never exceeding 2.5 °C. All calculated values of relative humidity are given to 0.01 percent relative humidity. This does not in any way imply an accuracy of 0.01 percent. The designated estimated uncertainties still give the best prediction of accuracy. It was felt that to fail to give the relative humidities to .01 percent would be discarding information, imprecise as it might be. Since the estimated uncertainties are given, we see no problem with presenting the values of relative humidity with figures far beyond their estimated uncertainties.

The uncertainties presented do not include uncertainties in the vapor pressure equation [22] or enhancement equations

TABLE 3. *Comparison of Relative Humidity Values of Selected Saturated Salt Solutions for Various Compilations*

Saturated Salt	Relative Humidity, %																				
	10 °C				20 °C						30 °C						40 °C				
	a	b	c	d	a	b	c	d	e	f	a	b	c	d	e	f	a	b	c	d	e
Potassium Hydroxide	12.34			13	9.32			9			7.38			7			6.26			6	
Lithium Chloride	11.29	14		13	11.31	12		12		15	11.28	12		12			11.21	11		11	
Potassium Acetate	23.38	21		24	23.11	22		23		20	21.61	22		22							
Magnesium Chloride	33.47	34	34.7	34	33.07	33	33.1	33	33		32.44	33	31.7	33	32		31.60	32	31.3	32	32
Sodium Iodide	41.83			42	39.65			39			36.15			36			32.88			33	
Potassium Carbonate	43.14	47	47.0	47	43.16	44	44.0	44	42		43.17	43	43.0	43							
Magnesium Nitrate	57.36	57		57	54.38	55		55			51.40	52		52			48.42	49		49	
Sodium Bromide					59.14					58											
Cobalt Chloride											61.83		61.9				55.48		56.6		
Potassium Iodide	72.11			72	69.90			70			67.89			68							
Sodium Chloride	75.67	76	76.9	76	75.47	76	75.8	76	76		75.09	75	75.1	75	75		74.68	75	74.4	75	75
Ammonium Chloride					79.23				79.2	79.2	77.90				79.5	79.5					
Potassium Bromide	83.75		86.0		81.67		84.0			84	80.27		82.0				79.43		80.0		
Ammonium Sulfate	82.06	82		82	81.34	81		81	81	81.0	80.63	80		80	81.1	81.1	79.91	79		79	81.1
Potassium Chloride	86.77	88	87.4	88	85.11	86	86.3	86	86		83.62	85	84.5	84	84		82.32	82	82.8	82	83
Potassium Nitrate	95.96	95	95.1	95	94.62	93	94.2	93			92.31	91	92.5	91			89.03	88	89.4	88	
Potassium Sulfate	98.18	98	98.2	98	97.59	97	97.1	97	96.5		97.00	96	96.6	96	96.5		96.41	96	96.1	96	96.5

a Values from this work.
b Values from references 24 and 25 which are identical.
c Values from reference 26.
d Values from reference 27.
e Values from reference 28.
f Values from reference 29.

[23] used. The results presented are therefore for the exact values of references [22] and [23]. The enhancement factor for a saturated salt solution in air is not known precisely. Analysis of the factors involved indicate that at one atmosphere pressure or less, the difference between the enhancement factor over a saturated salt solution and over pure water is negligible. That is not the case at high pressures. The data presented are therefore considered valid near or below one atmosphere total pressure. If saturation vapor pressure values other than those given by Wexler [22] are used, the relative humidities should be multiplied by the ratio of these saturation vapor pressures to those of Wexler.

Many compilations of non-critically evaluated data on the equilibrium humidity of saturated salt solutions exist [24–38]. Table 3 is a comparison of values from this work and corresponding values taken from five of these other compilations at four temperatures. Of the listed compilations, only this work (column a) and Hickman's work (column d) give the sources of the data. Hickman's values (in column d) were directly copied from his cited references without modification. None of the compilations other than ours (column a) gives estimates of uncertainty. Therefore, one would logically conclude that the authors of those compilations consider their values to be uncertain only in the last figure presented. It is also likely that some of the values in one compilation came from the same sources as the values in other compilations—such a relationship appears to exist between column b and column d.

If we assume an uncertainty of 1/2 of the last digit in the values given in these other compilations, and if we add that uncertainty to the estimated uncertainty for the corresponding values in column a, we find that the values in column a (the results of this work) agree with the values in at least one of the other compilations to within this composite uncertainty at all points, except for:

Potassium carbonate at 10 °C
Sodium bromide at 20 °C
Ammonium chloride at 30 °C
Potassium bromide at 10 °C, 20 °C, and 30 °C
Potassium chloride at 10 °C, and 20 °C

It should be noted that this comparison of compilations is over a limited temperature range and for only 17 of the 28 salt solutions evaluated and collated in this paper.

6. Appendix

In all cases, the most fundamental measurements presented were used to calculate the actual relative humidity obtained by each investigator for each datum. No attempt was made to evaluate purity of water or solute or its effect in any investigation.

As a first step, all temperatures were converted from the temperature scale in which the data were presented into IPTS-68 temperature equivalents. Where the temperature scales were not given, a judgment was made as to the most likely temperature scale used, based on the date of the research.

Likewise, where vapor pressures based on vapor pressure equations or tables were given, these were converted to new vapor pressures based on the Wexler formulation. In the case of reported relative humidities based on dew-point measurements, the dew-point temperature was reconstructed from a knowledge of the vapor pressure equation used. From the reported control temperature and the reconstructed dew-point temperature a new relative humidity was calculated using the Wexler and Greenspan equations for vapor pressures and enhancements factors, respectively.

Where the isopiestic method was used with sulfuric acid as the isopiestic solution, the values of Shankman [39] for sulfuric acid activity were used to determine the relative humidity of the saturated salt solution. This was done (1) for consistency, because many of the researchers had done likewise; (2) because Shankman described his experimental work in sufficient detail to enable us to judge its quality and to estimate the uncertainty in his work; and (3) his values appeared to be the most accurate available.

In determining estimates of total uncertainty for each datum, the uncertainty was taken as the square root of the sums of individual uncertainties (in terms of relative humidity) squared as described by Ku [40]. Individual uncertainties involved in the individual measurements were obtained from the investigators' own estimates where these seemed reasonable. Where the investigator did not present a reasonable estimate of uncertainty for a particular parameter, this author made his own estimate of the uncertainty of that parameter based on his judgment of the investigator's work and his estimate of the state of the art at the time of the investigation. The relative humidity uncertainty associated with each of the parameter uncertainties was obtained by calculating the relative humidity with and without the uncertainty added to the related parameter, the difference being the relative humidity uncertainty for that particular parameter.

In some cases the individual parameter uncertainties are not independent in their effect on the relative humidity uncertainty. A case in point is the relative vapor pressure measurement method. In this technique, the individual temperature and pressure measurement uncertainties are of no great consequence, it is the estimates of the temperature difference and the *pressure difference* in the two pressure measurements that are significant. In addition, an estimate of the degree of equilibrium achieved is of significance. In these types of situations, estimates of the differences were used in lieu of estimates of the individual measurements.

In the case of the relative humidity sensor calibration technique, an estimate of the calibration uncertainty as well as temperature uncertainty were used. In the isopiestic technqiue, the relevant uncertainties are the temperature difference, the concentration determination, the uncertainty in equilibrium and the uncertainty in the reference solution data.

Composite uncertainties for each datum based on the square root of the sum of the individual parameter uncertainties squared were thus obtained.

As stated earlier, these estimates of uncertainties are the result of subjective judgments as well as objective estimates. For the great preponderance of data presented in this paper, these judgments have a minor effect on the relative humidity values as well as the total uncertainty, as was shown by the small difference obtained for the three different methods of weighting.

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Frequency Dependence of Intrinsic Stress and Birefringence Tensor of Bead/Spring Model of Polymer Solutions

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The recently obtained complete solution of the simultaneous diagonalization of matrices **H A** and **H** in the hydrodynamic diffusion equation has basically changed the diagonal values ν_p of the symmetric matrix **H** of hydrodynamic interaction between all the beads of the elastic random coil model of the isolated macromolecule in solution. Since these values enter explicitly the expressions for the intrinsic stress and refractive index tensor in an alternating flow field if based on the concept of internal viscosity of the model one had to recalculate all values obtained formerly by using the then generally accepted erroneous set of ν_p data. The new ν_p equal unity independent of p while the old values were larger than 1 for small p and smaller for large p. Hence their too large contributions in the former range are partially compensated by their too small contributions in the latter region. As a consequence in the whole range investigated, between 3 and 300 chain links, the differences in rheological and rheooptical effects are relatively small, up to a factor of 2, although at higher link number the differences tend to grow with the logarithm of this number.

Key words: Bead-spring model; eigenvalues; frequency response; intrinsic optical tensor; intrinsic stress tensor; polymer solution.

1. Introduction

The correct simultaneous diagonalization [1][1] of **H A** and **H** matrices in Zimm's hydrodynamic equation [2] for the ideally flexible necklace model of randomly coiled isolated linear macromolecule in laminar flow makes possible a more adequate calculation of intrinsic stress tensor in all those cases where the coil is not yet noticeably deformed by the flow. Such a zero gradient case includes the frequency dependence of viscosity [2], shear modulus, shear birefringence, normal stress difference, and acoustic birefringence but not the gradient dependence of these effects.

The main change introduced by the new solution as compared with the older incomplete solutions [3–8] is not in the eigenvalues λ_p of **H A**

$$\mathbf{Q}^{-1}\,\mathrm{H}\,\mathbf{A}\,\mathbf{Q} = \mathbf{\Lambda} \tag{1}$$

which were already calculated correctly in recent papers [6–8] and even tabulated for Z between 1 and 15 and $h^* = (3/\pi)^{1/2}\, a_h/b_0 = .01, .1, .2, .3$, [6] and for $Z = 250$, $h^* = .3$ and $Z = 300$, $h^* = 0.4$ [1]. Here a_h is the hydrodynamic radius of the bead, $Z + 1$ is the number of beads, Z is the number and b_0 the root mean square length of the links. The difference is in the diagonal elements ν_p of the tensor

$$\mathbf{Q}^{-1}\,\mathbf{H}\,\mathbf{Q}^{-1T} = \mathbf{N} = \mathbf{1} \tag{2}$$

which turns out to be the unity tensor with all $\nu_p = 1$. This makes the diagonal elements of

$$\mathbf{M} = \mathbf{Q}^T\,\mathbf{A}\,\mathbf{Q} = \mathbf{\Lambda}/\mathbf{N} = \mathbf{\Lambda} \tag{3}$$

agree with those of $\mathbf{\Lambda}$, i.e. $\mu_p = \lambda_p$. Here **Q** is the transformation matrix of the original $3(Z + 1)$ dimensional vector $\boldsymbol{r}$ of bead coordinates to that of dimensionless normal coordinates $\boldsymbol{u}$

$$\boldsymbol{r} = b_0\,\mathbf{Q}\,\boldsymbol{u} \tag{4}$$

and $\mathbf{Q}^T$ its transpose.

Equation 3 completely differs from the original estimate [3] that in first approximation the diagonal elements of the matrix **M** equal the eigenvalues λ_{pR} of the Rouse model with vanishing hydrodynamic interaction, i.e.

$$\mu_{pZ}^{(1)} = \lambda_{pR} = 4\,\sin^2\,[p\pi/2(Z + 1)] \tag{5}$$

and hence

$$\nu_{pZ}^{(1)} = \lambda_{pZ}/\lambda_{pR}. \tag{6}$$

[1] Figures in brackets indicate the literature references at the end of this paper.

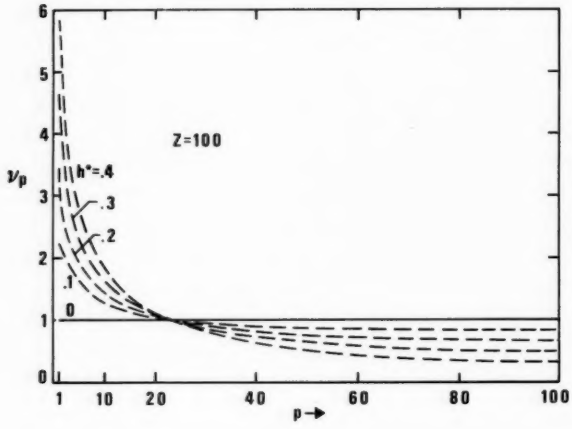

FIGURE 1. *Diagonal elements* ν_p *(new theory) and* $\nu_p^{(1)} = \lambda_{pZ}/\lambda_{pR}$ *(old theory, broken lines) for* Z = 100 *and* h* = 0, .1, .2, .3, .4.
For $h^* = 0$ (Rouse) the values of both theories coincide.

The subscripts Z and R refer to Zimm and Rouse [9] model, respectively. Such an estimate was based [3] on the supposition that the transformation matrix **Q** changes so little by the introduction of hydrodynamic interaction that **M** remains practically the same as in the free draining case, i.e. $\mathbf{M} = \mathbf{\Lambda}_R$.

The diagonal elements ν_p for $Z = 100$ and $h^* = 0$ (Rouse), .1, .2, .3, and .4 (Zimm) are plotted in figure 1 and the eigenvalues λ_p collected in table 1. The old values of $\nu_p^{(1)} = \lambda_{pZ}/\lambda_{pR}$ are connected with a broken line. They are partially situated below and partially above $\nu_p = 1$. This reduces the differences between the old and new values in quantities dependent on ν_p. They show up in the excess stress tensor as soon as internal viscosity, defined by the frictional parameter φ, is explicitly considered. The very large old values ν_p for small p do not matter very much because in all formulae they are multiplied by very small values $\varphi_p = p\varphi/Z$. Since the differences between old and new ν_p increase with h^*, in that which follows, the comparison of calculated effects will be mainly done for $h^* = .4$, i.e., for a very large hydrodynamic interaction. The differences are smaller for smaller h^* and of course disappear for the free draining coil with $h^* = 0$ where $\lambda_{pZ} = \lambda_{pR}$.

The new values μ_p and ν_p do not enter the conventional expressions for the intrinsic stress or birefringence tensor of perfectly flexible necklace model so that no changes occur in these quantities. The situation is completely different if one considers the effects of internal viscosity which depend on ν_p [10–26]. They will be most conspicuous in the values of viscosity corresponding to high frequency flow field and in the phase angle between the stress and strain rate or between the birefringence and strain rate.

The interaction tensor **H** depends on the inverse intrabead distances $1/r_{jk}$ which makes the hydrodynamic diffusion equation intrinsically non-linear. By replacing $1/r_{jk}$ with its average value $\langle 1/r_{jk} \rangle$ the tensor **H** becomes a constant which makes the diffusion equation linear and hence allows the introduction of normal coordinates according to eqs (1) to (4). Such a procedure eliminates the possibility of any realistic consideration of the gradient dependence of any rheological or rheooptical effect because it does not take into account the change of shape of the random coil in flow which expands the molecule and hence increases the interbead distances r_{jk}. Note also that by preaveraging over all angles between the velocity and the interbead vector the formulation of **H** as function of $1/r_{jk}$ completely evades the consideration of anisotropy of hydrodynamic interaction which by itself yields a gradient dependence of intrinsic viscosity [27] large enough for explaining experimental data.

The general toleration of such a profound modification of hydrodynamic interaction by the replacement of $1/r_{jk}$ with its average $\langle 1/r_{jk} \rangle$ makes hard to understand the almost general objections to the introduction of internal viscosity as a resistance of the necklace model against the deformational component of the normal eigenmodes [28–30]. If one accepts the rather questionable linearization of the hydrodynamic diffusion equation one has to accept also the next step, i.e., the concept of internal viscosity based on this linearity and its introduction in such a manner that the mathematical treatment remains as simple as possible.

In that which follows the results of the new theory will be compared with those of the old one for $h^* = .4$ and $Z = 100$ in the whole frequency range and the dependence of the limiting values for $\omega = \infty$ on Z in the range between $Z = 3$ and 300 and on h^* in the range between .1 and .4. In all cases the ratio between the internal viscosity coefficient φ and the frictional coefficient of the bead $f = 6\pi a_h \eta_s$ will be assumed constant, $\varphi/f = 2$. Here η_s is viscosity of the solvent. The subscript s applies to the properties of the solvent. The corresponding non-subscripted quantities relate to solution.

2. Internal Viscosity

The concept of internal viscosity was introduced in order to express the inability of the randomly coiled polymer molecule to change rapidly its shape [31, 32, 10, 11]. Such changes occur during the rotation of the macromolecule in a flow with a rotational component, e.g., the laminar flow with transverse gradient, when the individual segments are alternatively passing from the direction of compression to the direction of extension and vice versa. The directions of maximum compression and extension of the volume element are in the flow plane perpendicular to each other. The rapidity of change is given by the transverse gradient which equals twice the angular velocity of the ideally flexible coil which rotates with the volume element. The other case is the oscillating flow field where the oscillation frequency determines the rapidity of change from compression to extension and vice versa.

In the limiting cases of zero gradient and zero frequency the deformation inability of the macromolecule does not play any role. All the changes occur so slowly that the effects are identical for completely rigid and ideally flexible coils if only their conformational distributions agree with each other. With increasing gradient and/or frequency, however, the time effects are playing a gradually increasing role. They are maximum in the second Newtonian regime corresponding to $\dot{\gamma} \to \infty$ or $\omega \to \infty$.

The rigidity of the macromolecule can be assigned to different properties of the chain. It can be caused by the

TABLE 1. *Eigenvalues λ_p for $Z = 100$ and $h^* = 0$ (Rouse), .1, .2, .3, .4 (Zimm)*

p	$H^* = 0$	.1	.2	.3	.4	p	$h^* = 0$	.1	.2	.3	.4
1	0.000967	0.002170	0.003345	0.004506	0.005643	51	2.03111	1.7822	1.5334	1.2846	1.0359
2	.003869	.007318	.010718	.014084	.017417	52	2.09329	1.8320	1.5707	1.3094	1.0483
3	.008701	.014650	.020541	.026383	.032173	53	2.15538	1.8815	1.6077	1.3339	1.0602
4	.015460	.023986	.032447	.040848	.049177	54	2.21731	1.9308	1.6443	1.3579	1.0716
5	.024139	.035175	.046144	.057043	.067854	55	2.27904	1.9799	1.6807	1.3816	1.0826
6	.034730	.048140	.061482	.074746	.087907	56	2.34050	2.0286	1.7167	1.4049	1.0932
7	.047220	.062802	.078315	.093745	.10906	57	2.40153	2.0770	1.7523	1.4277	1.1033
8	.061602	.079111	.096552	.11391	.131113	58	2.46236	2.1249	1.7875	1.4502	1.1130
9	.077859	.097010	.11610	.13509	.15395	59	2.52265	2.1725	1.8223	1.4722	1.1223
10	.095974	.11646	.13688	.15721	.17740	60	2.58244	2.2195	1.8566	1.4938	1.1311
11	.115932	.13742	.15884	.18017	.20135	61	2.64166	2.2661	1.8905	1.5150	1.1396
12	.137713	.15984	.18192	.20390	.22571	62	2.70026	2.3120	1.9238	1.5357	1.1477
13	.161295	.18370	.20605	.22831	.25040	63	2.75819	2.3574	1.9566	1.5559	1.1554
14	.186656	.20895	.23120	.25335	.27533	64	2.81538	2.4021	1.9889	1.5757	1.1627
15	.213771	.23556	.25730	.27896	.30044	65	2.87178	2.4462	2.0206	1.5950	1.1697
16	.242614	.26350	.28434	.30509	.32566	66	2.92734	2.4895	2.0517	1.6139	1.1763
17	.273158	.29272	.31224	.33169	.35095	67	2.98200	2.5321	2.0821	1.6323	1.1826
18	.305372	.32320	.34099	.35870	.37623	68	3.03571	2.5738	2.1120	1.6502	1.1885
19	.339225	.35490	.37053	.38610	.40148	69	3.08842	2.6148	2.1411	1.6676	1.1941
20	.374681	.38778	.40084	.41383	.42664	70	3.14007	2.6548	2.1696	1.6845	1.1995
21	.411719	.42180	.43186	.44186	.45168	71	3.19063	2.6940	2.1974	1.7009	1.2045
22	.450288	.45694	.46358	.47015	.47655	72	3.24003	2.7323	2.2245	1.7168	1.2092
23	.490356	.49316	.49594	.49867	.50123	73	3.28823	2.7695	2.2508	1.7322	1.2137
24	.531886	.53041	.52892	.52738	.52568	74	3.33518	2.8058	2.2764	1.7471	1.2179
25	.574835	.56867	.56248	.55626	.54987	75	3.38085	2.8410	2.3012	1.7614	1.2218
26	.619163	.60788	.59659	.58527	.57378	76	3.42518	2.8752	2.3252	1.7753	1.2255
27	.664827	.64802	.63122	.61438	.59738	77	3.46812	2.9083	2.3484	1.7886	1.2290
28	.711782	.68905	.66632	.64356	.62065	78	3.50965	2.9402	2.3708	1.8014	1.2322
29	.759984	.73093	.70187	.67279	.64357	79	3.54972	2.9710	2.3924	1.8137	1.2352
30	.809386	.77361	.73784	.70205	.66613	80	3.58829	3.0007	2.4131	1.8255	1.2380
31	.859939	.81706	.77419	.73130	.68829	81	3.62532	3.0291	2.4329	1.8367	1.2406
32	.911596	.86124	.81089	.76053	.71005	82	3.66078	3.0563	2.4518	1.8474	1.2430
33	.964305	.90610	.84790	.78970	.73140	83	3.69464	3.0823	2.4699	1.8575	1.2453
34	1.01802	.95160	.88521	.81881	.75231	84	3.72685	3.1069	2.4870	1.8672	1.2474
35	1.07268	.99771	.92277	.84782	.77279	85	3.75737	3.1303	2.5033	1.8762	1.2493
36	1.12824	1.0444	.96055	.87672	.79281	86	3.78624	3.1524	2.5186	1.8848	1.2510
37	1.18464	1.0916	.99852	.90548	.81238	87	3.81335	3.1731	2.5329	1.8928	1.2526
38	1.24183	1.1392	1.0367	.93410	.83148	88	3.83871	3.1925	2.5464	1.9002	1.2541
39	1.29975	1.1873	1.0749	.96254	.85011	89	3.86229	3.2105	2.5588	1.9071	1.2554
40	1.35835	1.2358	1.1133	.99079	.86826	90	3.88407	3.2272	2.5703	1.9134	1.2566
41	1.41758	1.2846	1.1517	1.0188	.88592	91	3.90403	3.2424	2.5808	1.9192	1.2577
42	1.47736	1.3338	1.1902	1.0467	.90311	92	3.92215	3.2563	2.5904	1.9245	1.2586
43	1.53758	1.3832	1.2287	1.0742	.91980	93	3.93840	3.2687	2.5989	1.9292	1.2595
44	1.59839	1.4328	1.2671	1.1016	.93601	94	3.95278	3.2796	2.6065	1.9333	1.2602
45	1.65952	1.4825	1.3056	1.1286	.95173	95	3.96527	3.2892	2.6130	1.9369	1.2608
46	1.72098	1.5324	1.3439	1.1554	.96696	96	3.97586	3.2972	2.6186	1.9400	1.2614
47	1.78270	1.5824	1.3821	1.1819	.98171	97	3.98454	3.3038	2.6232	1.9425	1.2618
48	1.84464	1.6324	1.4202	1.2021	.99597	98	3.99130	3.3090	2.6267	1.9444	1.2621
49	1.90673	1.6824	1.4581	1.2339	1.0098	99	3.99613	3.3127	2.6292	1.9458	1.2624
50	1.96890	1.7324	1.4959	1.2594	1.0231	100	3.99903	3.3149	2.6308	1.9466	1.2625

energy barrier separating the gauche and trans conformations which makes any conformational change more time consuming than in the case of perfectly soft model [10]. Since the height of the energy barrier is independent of the viscosity of the solvent its relative effect as measured by the ratio of internal frictional resistance φ caused by the barrier and the frictional resistance f of the segment decreases with the viscosity of the solvent. The macromolecule acts as very rigid in a low viscosity liquid, e.g., acetone with $\eta_s = .322$cPoise $= 32.2$ mNs/m^3, and as very flexible in a high viscosity solvent, e.g., Aroclor with η_s up to 100 Poise (= 1 kNs/m^3) and higher.

Another cause of slow molecular response to the rapidly changing flow field resides with the conformational restraints of the chain which permit only an interchange of gauche and trans conformations [20, 23, 24]. With almost rigid length of valency bonds this means that most changes of length and position of any chain segment require a much larger segment displacement than formulated in the ideally flexible necklace model which does not consider any inherent limitation of bead motion. Generally an axial displacement of the segment requires also some lateral displacement and vice versa. As a consequence the resistance of beads to position change is larger than assumed on the basis of hydrodynamic radius a_h.

The ratio of the so obtained coefficient φ to f is independent of solvent viscosity because φ and f are both proportional to η_s. Their ratio just measures the ratio of true displacement to the minimum displacement explicitely considered in the diffusion equation. It seems to be close to 2 for vinyl polymers

The effect of internal viscosity is formulated in the system of normal modes [10]. For the pth normal mode of deformation one has a resistance coefficient $\varphi\, p/Z$. Such a choice is reasonable for both origins of internal viscosity as just discussed. In the first case one can argue that the changes to comply with any deformational mode are linearly increasing with the number of chain atoms between subsequent nodes, i.e., with Z/p, because a conformational change takes place with equal probability at any of these chain atoms. This makes the resistance increase with p/Z. In the second case the displacement at lower modes can be achieved in many ways so that the actual lengthening of displacement path is much less noticeable than at higher modes where the conformational restrictions are soon becoming of overwhelming importance.

One may argue that the whole concept of internal viscosity can be discarded because it is not based on some strictly fundamental analysis of chain dynamics. It was indeed introduced in a rather pragmatic manner which also permitted an easy mathematical treatment [10]. But it turns out that all more detailed treatments of Brownian motion of beads or of correlation between the motion of two or more beads [33–35] lead to some, often hidden, statement of molecular rigidity which is needed for the results of such a study to reproduce the characteristic rheological features of polymer systems, e.g., the non-vanishing limiting intrinsic viscosity at very high frequency [36–51]. Such a state of affair seems more to support than to refute the concept of internal viscosity in spite of its more pragmatic than fundamental way of introduction.

3. The Distribution Function of the Beads

The continuity equation of the ideally flexible necklace in laminar flow which determines the distribution function $\psi(\mathbf{r}_0, \boldsymbol{r}_1 \cdots \boldsymbol{r}_Z)$ reads

$$\boldsymbol{\nabla}_r{}^T [\mathbf{v}\psi - (3D_0/b_0^2)\, \mathbf{H}\, \mathbf{A}\, \boldsymbol{r}\, \psi - D_0\, \mathbf{H}\, \boldsymbol{\nabla}_r\, \psi] = -\partial\psi/\partial t. \quad (7)$$

Here $D_0 = kT/f$ is the translational diffusion coefficient of the bead. By introduction of normal coordinates, eq (4), one transforms eq (7) into a system of $Z + 1$ partial differential equations

$$\boldsymbol{\nabla}_p [\mathbf{v}_p\, \psi_p - (3D_0/b_0^2)\lambda_p\, \boldsymbol{u}_p - (D_0/b_0^2)\nu_p\, \boldsymbol{\nabla}_p\, \psi_p] = -\partial\psi_p/\partial t \quad (8)$$

each depending only on the coordinates of the pth eigenmode. Note that $\mathbf{v}_p$ in normal coordinates has the dimension s^{-1}. The distribution function of the coil is the product of all ψ_p

$$\psi(\boldsymbol{u}, t) = \psi_1(\boldsymbol{u}_1, t) \cdots \psi_Z(\boldsymbol{u}_Z, t). \quad (9)$$

The functions ψ_p depend on the kind of flow field $\mathbf{v}$. The 0th mode does not show up in ψ because it represents a uniform translation of the whole necklace which does not affect ψ.

The introduction of internal viscosity adds a viscous type resistance coefficient $\varphi_p = p\varphi/Z$ opposing the pth eigenmode of the true deformation rate of the coil. This rate is obtained by subraction of pure rotational velocity $\boldsymbol{\Omega} \times \boldsymbol{u}_p$ from the total deformation rate $\partial\boldsymbol{u}_p/\partial t$. This yields an internal viscosity force [10, 11]

$$\mathbf{F}_{ip} = -(p\varphi/Z)(\partial\boldsymbol{u}_p/\partial t - \boldsymbol{\Omega} \times \boldsymbol{u}_p)b_0. \quad (10)$$

If one introduces this force in the pth diffusion equation (eq (8)) one obtains after some rearrangements

$$(1 + \nu_p\varphi_p/f)^{-1}\, \boldsymbol{\nabla}_p \{[\mathbf{v}_p - (3D_0/b_0^2)\lambda_p\boldsymbol{u}_p + (\nu_p\varphi_p/f)\boldsymbol{\Omega} \times \boldsymbol{u}_p - (D_0/b_0^2)\nu_p\boldsymbol{\nabla}_p]\psi_p\} = -\partial\psi/\partial t. \quad (11)$$

The distribution function ψ_p depends on the kind of flow and on the angular velocity vertor $\boldsymbol{\Omega}$.

In a jet or plane flow with longitudinal gradient without a rotational flow component one has $\boldsymbol{\Omega} = 0$. In a flow with transverse gradient, $\mathbf{v} = \dot\gamma(\mathrm{y,o,o})$, the angular velocity equals $-\boldsymbol{\gamma}/2$

$$\boldsymbol{\Omega} = (0,\ 0,\ -\dot\gamma/2) \quad (12)$$

for relatively soft molecules which rotate in phase with the volume element. This is the case with practically all conventional macromolecules if the degree of polymerization is so high that a truly random coil is formed. Very short chains, chains with a great many double bonds, ladder type and multiple strand molecules, however, are more rigid and tend to rotate with a non-uniform angular velocity which depends on orientation of the molecule. It is different from that of he volume element. Assymptotically, at very high rigidity and fully extended shape of the macromolecule, it approaches that of rigid bodies, e.g., rods or ellipsoides. In that which follows only the case of practically undeformed relatively soft coils with $\boldsymbol{\Omega} = -\dot\gamma/2$ will be considered.

In the steady state flow with transverse gradient the pth eigenmode distribution function of the soft necklace reads

$$\psi_p(\xi_p, \eta_p, \xi_p) = \left(\frac{\mu_p}{\pi}\right)^{3/2}\left(\frac{1 + \beta_p'^2 - \beta_p{}^2}{1 + \beta_p'^2}\right)^{1/2} \exp\left(-\frac{\mu_p}{1 + \beta_p'^2}\{(1 + \beta_p'^2 - \beta_p{}^2)\xi_p{}^2 - 2\beta_p\xi_p\eta_p + [1 + \beta_p'(\beta_p' + \beta_p)]\eta_p{}^2) + (1 + \beta_p'^2)\zeta_p{}^2\}\right)$$

$$\beta_p = \dot\gamma b_0^2/6D_0\lambda_p$$

$$\beta_p' = \beta_p(1 + \nu_p\varphi_p/f). \quad (13)$$

The index p runs from 1 to Z. The value 0 is excluded. Without internal viscosity, $\varphi_p = 0$, one has $\beta'_p = \beta_p$ and one obtains the conventional distribution function. Note that eq (13) and the distribution function eq (6.1) in Ref. [1] refer to different flow fields: $\dot\gamma(y,\mathrm{o,o})$ in the former and $\gamma(z,\mathrm{o,o})$ in the latter case.

Equation (13) explicitely contains the diagonal terms λ_p, μ_p and ν_p. In the averages (dyadic formulation)

$$\langle \mathbf{r}^{\mathrm{T}} \mathbf{A} \mathbf{r} \rangle = b_0^2 \langle \boldsymbol{\upsilon}^{\mathrm{T}} \mathbf{M} \boldsymbol{\upsilon} \rangle = b_0^2 \sum_{p=1}^{Z} \mu_p \langle \boldsymbol{\upsilon}_p \boldsymbol{\upsilon}_p \rangle \qquad (14)$$

which appear in the intrinsic stress and optical tensor the coefficients μ_p drop completely because the averages $\langle \boldsymbol{\upsilon}_p \boldsymbol{\upsilon}_p \rangle$ are proportional to $1/\mu_p$. The coefficients ν_p, however, remain in β'_p as long as $\varphi \neq 0$. As already mentioned they are equal to unity (new theory) while formerly they were approximated by $(\lambda_Z/\lambda_R)_p = \lambda_p(h^*)/\lambda_p(h^* = 0) \neq 1$ (old theory).

In the oscillating flow field the gradient is a function of time

$$\dot{\gamma} = \gamma_0 e^{i\omega t}. \qquad (15)$$

The amplitude $\dot{\gamma}_0$ is so small that the molecule remains practically undeformed so that the zero gradient eigenvalues λ_p and diagonal elements ν_p, calculated for the coil at rest, are applicable.

4. The Intrinsic Stress Tensor

In dyadic formulation the intrinsic stress tensor reads

$$[\boldsymbol{\sigma}] = \lim_{c \to 0} \frac{\boldsymbol{\sigma} - \boldsymbol{\sigma}_s}{c} = \frac{N}{M} \langle \mathbf{r}^{\mathrm{T}} \mathbf{F} \rangle. \qquad (14)$$

Here N is Avogadro number, M is molecular weight, and $\mathbf{F}$ is the vector of forces exerted by the beads of the necklace model on the flowing liquid. One has in the space of normal coordinates

$$\mathbf{F} = (1 + \mathbf{N}\boldsymbol{\phi}/f)^{-1} \mathbf{Q}^{-1T} [(3kT/b_0)\, \mathbf{M}\, \boldsymbol{\upsilon} + b_0 \boldsymbol{\phi}(\mathbf{v} - \boldsymbol{\Omega} \times \boldsymbol{\upsilon}) + (kT/b_0)\, \boldsymbol{\nabla} \ln \psi] \qquad (15)$$

which yields

$$[\boldsymbol{\sigma}] = \frac{N}{M} [3kT \langle \boldsymbol{\upsilon}^{\mathrm{T}} \mathbf{M}\, \boldsymbol{\upsilon} \rangle + b_0^2 \langle \boldsymbol{\upsilon}^{\mathrm{T}}\, \boldsymbol{\phi}(\mathbf{v} - \boldsymbol{\Omega} \times \boldsymbol{\upsilon}) \rangle + kT \langle \boldsymbol{\upsilon}^{\mathrm{T}}\, \boldsymbol{\nabla} \ln \psi \rangle]. \qquad (16)$$

$$(\mathbf{1} + \mathbf{N}\boldsymbol{\phi}/f)^{-1}$$

The type of laminar flow shows up in $\mathbf{v}$ and $\boldsymbol{\Omega}$.

The bilinear coordinate averages in eq (16) can be derived from the diffusion equation, eq (11), by multiplication by ξ_p^2, $\xi_p \eta_p$, $\cdots$ and integration over the whole space.

5. Flow With Transverse Gradient

In the case of laminar flow with transverse gradient $\boldsymbol{v} + \dot{\gamma}(\mathrm{y},\mathrm{o},\mathrm{o})$, one obtains the set of linear differential equations

$$\begin{aligned}
\langle \xi_p^2 \rangle - \nu_p/3\lambda_p - 2\tau_p \dot{\gamma}(1 + \nu_p \varphi_p/2f) \langle \xi_p \eta_p \rangle &= -\tau'_p\ d\langle \xi_p^2 \rangle/dt \\
\langle \xi_p \eta_p \rangle - \tau_p \gamma(\nu_p \varphi_p/2f) \langle \xi_p^2 \rangle - \tau_p \dot{\gamma}(1 + \nu_p \varphi_p/2f) \langle \eta_p^2 \rangle &= -\tau'_p\ d\langle \xi_p \eta_p \rangle/dt \\
\langle \eta_p^2 \rangle - \nu_p/3\lambda_p + \tau_p \dot{\gamma}(\nu_p \varphi_p/f) \langle \xi_p \eta_p \rangle &= -\tau'_p\ d\langle \eta_p^2 \rangle/dt \\
\langle \eta_p \zeta_p \rangle + \tau_p \dot{\gamma}(\nu_p \varphi_p/2f) \langle \zeta_p \xi_p \rangle &= -\tau'_p\ d\langle \eta_p \zeta_p \rangle/dt \\
\langle \zeta_p^2 \rangle - \nu_p/3\lambda_p &= -\tau'_p\ d\langle \zeta_p^2 \rangle/dt \\
\langle \zeta_p \xi_p \rangle + \tau_p \dot{\gamma}(1 + \nu_p \varphi_p/2f) \langle \eta_p \zeta_p \rangle &= -\tau'_p\ d\langle \zeta_p \xi_p \rangle/dt
\end{aligned} \qquad (17)$$

The steady state solutions which apply after the complete decay of transient phenomena read

$$\begin{aligned}
\langle \xi_p^2 \rangle &= \frac{1}{3\mu_p} \left[1 + \frac{\gamma_0^2 \tau_p (\tau'_p + \tau_p)/2}{1 + i\omega\tau'_p} \left(1 + \frac{e^{2i\omega t}}{1 + 2i\omega\tau'_p} \right) \right] \\
\langle \xi_p \eta_p \rangle &= \frac{1}{3\mu_p} \frac{\gamma_0 \tau_p}{1 + i\omega\tau'_p} e^{i\omega t} \\
\langle \eta_p^2 \rangle &= \frac{1}{3\mu_p} \left[1 - \frac{\gamma_0^2 \tau_p (\tau'_p - \tau_p)/2}{1 + i\omega\tau'_p} \left(1 + \frac{e^{2i\omega t}}{1 + 2i\omega\tau'_p} \right) \right] \\
\langle \zeta_p^2 \rangle &= \frac{1}{3\mu_p} \\
\langle \eta_p \zeta_p \rangle &= \langle \zeta_p \xi_p \rangle = 0
\end{aligned} \qquad (18)$$

The averages are cut off beyond the lowest power $\dot\gamma$ which is needed later in zero gradient expressions for intrinsic viscosity, normal stress difference and birefringence. These averages have to be inserted in the expression for the intrinsic stress tensor.

$$[\sigma] = (N/M)[3kT\langle \boldsymbol{\upsilon}^{\mathrm{T}}\mathbf{M}\,\boldsymbol{\upsilon}\rangle + (\dot\gamma b_0^{\,2}/2)\langle \boldsymbol{\upsilon}^{\mathrm{T}}\boldsymbol{\phi}(\boldsymbol{\eta}, \boldsymbol{\xi}, o)\rangle - kT\mathbf{1}] \times (\mathbf{1} + \mathbf{N\Phi}/f)^{-1} \quad (19)$$

yielding the frequency dependence of intrinsic viscosity

$$\begin{aligned}[\eta] &= [\eta]'_\omega - i[\eta]''_\omega \\ &= \lim_{c\to 0}\frac{\eta - \eta_s}{c\eta_s} = \lim_{c\to 0}\frac{\sigma_{12}{}^* - \sigma_{12s}}{c\sigma_{12s}} = [\sigma_{12}]^*/\eta_s\dot\gamma \\ &= \frac{RT}{M\eta_s}\sum_{p=1}^{Z}\left(\frac{3\mu_p}{\dot\gamma}\langle\xi_p\eta_p\rangle + \frac{b_0^{\,2}\varphi_p}{2kT}\langle\eta_p{}^2\rangle\right)\Big/\left(1+\frac{\nu_p\varphi_p}{f}\right) \\ &= \frac{RT}{M\eta_s}\sum\tau_p\frac{1+i\omega(\tau'_p - \tau_p)}{1+i\omega\tau'_p} \\ &= \frac{RT}{M\eta_s}[\mathrm{I} + \mathrm{IV} - i(\mathrm{II} - \mathrm{III})]/\omega\end{aligned}$$

$$\tan\delta_\eta = (\mathrm{II} - \mathrm{III})/(\mathrm{I} + \mathrm{IV}). \quad (20)$$

The absolute value of intrinsic viscosity $[\eta]_\omega M\eta_s/RT$ and the phase angle δ_η as function of $\omega\tau_1$ are plotted in figure 2 for $Z = 100$, $\varphi/f = 2$, $h^* = .4$ according to old and new theory.

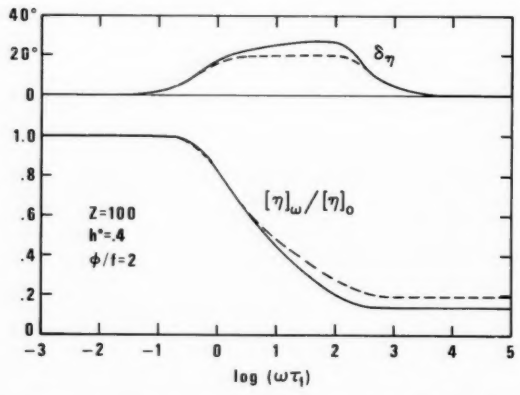

FIGURE 2. *Relative intrinsic viscosity* $[\eta]_\omega/[\eta]_0$ *and phase angle* δ_η *for* Z = 100, h* = .4, *and* φ/f = 2 *as function of* $\omega\tau_1$ *according to new (full line) and old (broken line) theory.*

A rather similar but not identical expression applies to intrinsic streaming birefringence

$$\begin{aligned}[\Delta n]_\omega{}^* &= [\Delta n]'_\omega - [\Delta n]''_\omega \\ &= \lim_{c\to 0}\frac{\Delta n^* - \Delta n_s}{cn_s\eta_s\gamma} = \lim_{c\to 0}\frac{\Delta n^* - \Delta n_s}{cn_s\sigma_{12s}} \\ &= K\frac{RT}{M\eta_s}\sum_{p=1}^{Z}\frac{2\mu_p}{\dot\gamma}\langle\xi_p\eta_p\rangle\Big/\left(1+\frac{\nu_p\varphi_p}{f}\right) \\ &= \frac{4\pi}{5}\left(\frac{n^2+2}{3n}\right)^2\frac{N\alpha_1 - \alpha_2)}{M\eta_s}\sum\frac{\tau_p}{1+i\omega\tau'_p} \\ &= K\frac{RT}{M\eta_s}(\mathrm{I} - i\mathrm{II})/\omega\end{aligned}$$

$$\tan\delta_n = \mathrm{II}/\mathrm{I}. \quad (21)$$

In the case of dynamic birefringence Δn is the difference between the refractive indices in the diagonal direction in the first and second quadrant. The extinction angle $\chi = 45°$ as long as the gradient amplitude $\dot\gamma$ is small enough. The birefringence $[\Delta n]_\omega M\eta_s/KRT$ and the phase angle δ_n are plotted in figure 3 for the same values of Z, φ/f and h^* as in figure 2.

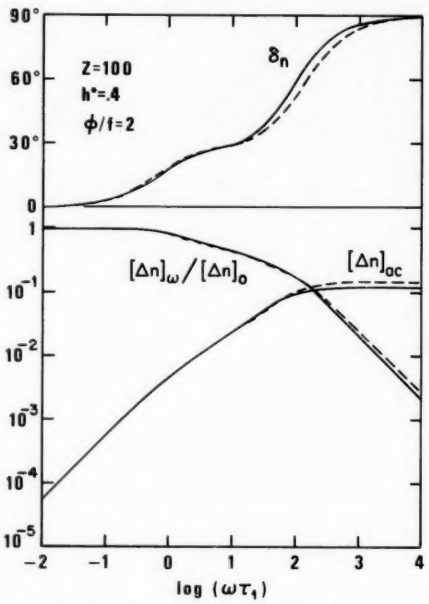

FIGURE 3. *Relative intrinsic streaming birefringence* $[\Delta n]_\omega/[\Delta n]_0$ *intrinsic accoustic birefringence* $[\Delta n]_{ac}$ *and phase angle* δ_n *for* Z = 100, h* = .4, *and* φ/f = 2 *as function of* $\omega\tau_1$ *according to new (full line) and old (broken line) theory.*

The meaning of the symbols in eqs (17) to (21) is as follows:

$$\tau_p = b_0^2/6D_0\lambda_p$$

$$\tau_p' = \tau_p(1 + \nu_p\varphi_p/f)$$

$$\tau_p' - \tau_p = \tau_p\nu_p\varphi_p/f$$

$$K = \frac{4\pi}{5}\left(\frac{n^2+2}{3n}\right)^2\left(\frac{\alpha_1 - \alpha_2}{kT}\right)$$

$$\mathrm{I} = \sum \omega\tau_p/(1 + \omega^2\tau_p'^2)$$

$$\mathrm{II} = \sum \omega^2\tau_p\tau_p'/(1 + \omega^2\tau_p'^2)$$

$$\mathrm{III} = \sum \omega^2\tau_p(\tau_p' - \tau_p)/(1 + \omega^2\tau_p'^2)$$

$$\mathrm{IV} = \sum \omega^3\tau_p\tau_p'(\tau_p' - \tau_p)/(1 + \omega^2\tau_p'^2)$$

The sums III and IV go to zero for vanishing internal viscosity $\varphi \to 0$. In this limiting case the intrinsic viscosity and streaming birefringence are proportional to each other. Here R is the gas constant, K is the rheooptical coefficient, n is refractive index, δ is the phase angle between the flow gradient and viscosity or birefringence, α_1 and α_2 are the optical polarizabilities of the link in the directions parallel and perpendicular to the link respectively.

Both definitions of intrinsic viscosity and birefringence in eqs (20) and (21) tend to make the intrinsic values as much as possible independent of the specific properties of the solvent, i.e., of η_s and n_s which influence the orientational forces, rigidity and optical anistropy of the dissolved macromolecule [52].

It is important to note that as a consequence of the new terms III and IV, i.e., $\langle\eta_p^2\rangle$, caused by the introduction of internal viscosity the expressions for intrinsic viscosity and streaming birefringence, eq. (20) and (21), respectively, are not proportional to each other. Hence the rheooptical law does not apply to such a model. In particular $[\Delta n]_\omega$ cannot be written as $K[\eta]\omega \sim [\sigma]_{12}$.

The proportionality, however, still holds in the first Newtonian region, $\omega \to 0$, where all the terms but I/ω go to zero. This means that the intrinsic viscosity $[\eta]$ and the Maxwell constant $[\Delta n]$ and hence the stress and the optical tensor are proportional to each other for $\dot\gamma \to 0$ and $\omega \to 0$. This is the case in most applications of flow stress mapping by means of streaming birefringence of dilute polymer solutions.

With increasing frequency and finite internal viscosity, $[\Delta n]_\omega$ goes to zero while $[\eta]_\omega$ tends to finite value. The rheooptical law breaks down completely. In this second Newtonian range the intrinsic viscosity is independent of frequency. One derives from eq (20)

$$[\eta]_\infty = \frac{RT}{M\eta_s}\sum_{p=1}^{z}\frac{\tau_p}{1 + f/\nu_p\varphi_p}. \qquad (23)$$

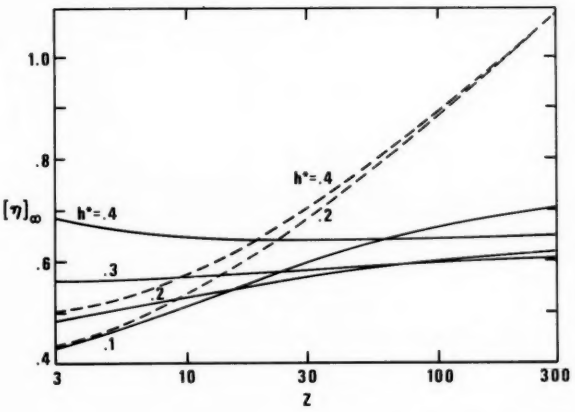

FIGURE 4. *Second Newtonian intrinsic viscosity* $[\eta]_\infty$ *as function of number of links* Z *and hydrodynamic interaction* h *as parameter for* $\varphi/f = 2$.
New (full line) and old (broken line) theory.

The limiting values $[\eta]_\infty M\eta_s/RT$ for Z between 3 and 300 and $h^* = .1, .2, .3, .4$ are plotted in figure 4 for the new (full line) and old (broken line) theory. One sees that the absolute values for $\nu_p = 1$ and $\nu_p^{(1)} = \lambda_{pZ}/\lambda_{pR}$ differ by less than a factor of 2. But their dependence on Z, i.e., on molecular weight, is just the opposite for $h^* = .4$. In the incorrect formulation of the old theory $[\eta]_\infty$ slightly increases with Z while in the correct formulation of the new theory it decreases with Z. Such a dependence on Z is much more in agreement with experimental data on polystyrene in Aroclor [44]. The second Newtonian viscosity $[\eta]_\infty$ is 14.3 cm^3/g if one goes with M from 20,000 to 860,000. The old theory yields a steady increase of $[\eta]_\infty$ with M in sharp disagreement with these data.

The often used real and imaginary part of intrinsic shear modulus

$$[G]^* = [G]' + i[G]'' = i\omega\eta_s[\eta]_\omega^*$$

$$= \frac{1}{\dot\gamma}[\sigma_{12}]^* = \lim_{c\to 0}\frac{\sigma_{12}^* - \sigma_{12s}}{c\dot\gamma} \qquad (24)$$

are plotted in figure 5. The difference between the old and new theory is relatively small for $Z = 100$ but would be larger for $Z = 300$.

The consequence of the non-vanishing second Newtonian viscosity, $[\eta]_\infty \neq 0$, is the linear increase of $[G]'$ with $\omega\tau_1$ in the assymptotic high frequency region. Such a behavior is in perfect agreement with experimental data on polystyrene in highly viscous Aroclor [44–51]. These data together with the zero gradient intrinsic orientation data of streaming birefringence of polystyrene in solvents of increasing viscosity [53] constitute the main support of the theory.

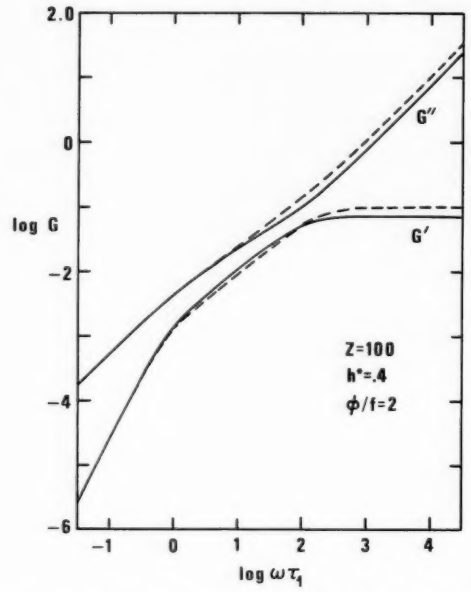

FIGURE 5. *Intrinsic shear moduli* [G]′ *and* [G]″ *for* Z = 100, h* = .4, *and* $\varphi/f = 2$ *as functions of* $\omega\tau_1$ *according to new (full line) and old (broken line) theory.*

The intrinsic first normal stress difference turns out to be

$$[\sigma_{11}-\sigma_{22}]^* = \frac{RT}{M}\sum_{p=1}^{Z}\left(3\mu_p\langle\xi_p^2-\eta_p^2\rangle+\frac{\dot\gamma b_0^2\varphi_p}{kT}\langle\xi_p\eta_p\rangle\right)\Big/(1+\nu_p\varphi_p/f)$$

$$= \frac{RT}{M}\gamma_0^2\sum_{p=1}^{Z}\frac{\tau_p^2}{1+i\omega\tau_p'}\cdot\left[1+\left(\frac{1}{1+2i\omega\tau_p'}+\frac{\tau_p'-\tau_p}{\tau_p}\right)e^{2i\omega t}\right] \qquad (25)$$

$$= A^*e^{2i\omega t}+B^*$$

while the second normal stress difference vanishes in all isolated necklace models with ideal elastic links independent of internal viscosity. In applying eq (25) one must not forget that the phase angle δ_1 of A^* is dependent only on the factor of exp $(2i\omega t)$ and that the angle δ_2 only reduces the constant vertical displacement to $B\cos\delta_2$ but does not yield any phase shift.

The term 1 in the parenthesis, i.e., B^*, keeps the first normal stress difference positive during the whole period up to very high frequencies. The oscillation is taking place with twice the frequency of the flow field. All these effects are very much the same as in the case of no internal viscosity. The difference is mainly in the replacement of τ_p by τ'_p and the term proportional to $\tau'_p - \tau_p$. The amplitude A of the oscillating term

$$A^* = Ae^{-i\delta_1} = \frac{RT}{M}\dot\gamma_p^2\sum_{p=1}^{Z}\frac{\tau_p}{1+i\omega\tau_p'}\left(\frac{1}{1+2i\omega\tau_p'}+\frac{\tau_p'-\tau_p}{\tau_p}\right)[1+2\omega^2\tau_p'(2\tau_p'-\tau_p)]$$

$$= \frac{RT}{M}\dot\gamma_0^2\sum_{p=1}^{Z}\tau_p^2\frac{-i\omega[\tau_p'+2\tau_p+4\omega^2\tau_p'^2(\tau_p'-\tau_p)]}{(1+\omega^2\tau_p'^2)(1+4\omega^2\tau_p'^2)} \qquad (26)$$

is proportional to the square of the amplitude of the oscillating gradient as in the case of no internal viscosity. The value $(A/\dot\gamma_0^2)(M/RT)$, the phase angle δ_1, and the frequency independent displacement

$$(B\cdot\cos\delta_2/\dot\gamma_0^2)(M/RT) = \sum_{p=1}^{Z}\frac{\tau_p^2}{1+\omega^2\tau_p'^2} \qquad (27)$$

are plotted in figure 6 as functions of $\omega\tau_1$ for $Z = 100$ and $h^* = .4$. Both quantities A and B are going to zero with increasing frequency. In contrast to intrinsic viscosity the limiting first normal stress difference, at $\omega \to \infty$, does not become finite by introduction of internal viscosity although it goes to zero more slowly, as ω^{-1} instead of as ω^{-3}.

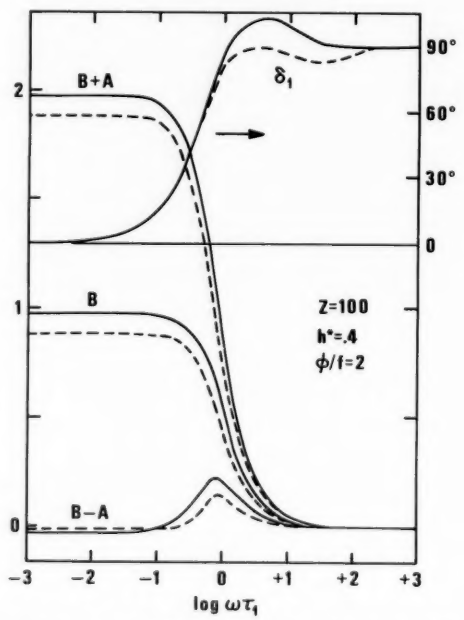

FIGURE 6. *The coefficient* B, *the sum* B + A, *the difference* B − A *of the relative intrinsic normal stress difference* $[\sigma_{11}-\sigma_{22}]_\omega/[\sigma_{11}-\sigma_{22}]_0 = A\,e_1^{2i\omega\tau-i\delta_1} + B$ *for* Z = 100, h* = .4 *and* $\varphi/f = 2$ *as functions of* $\omega\tau_1$ *according to new (full line) and old (broken line) theory.*

6. Flow With Longitudinal Gradient

In jet flow, $\mathbf{v} = \dot{\gamma}(-x/2, -y/2, z)$ the intrinsic stress tensor

$$[\sigma] = \frac{N_A}{M}[3kT\langle \mathbf{u}\,\mathbf{M}\,\mathbf{u}\rangle + (\dot{\gamma}b_0^2/2)\langle \mathbf{u}\,\phi(-\boldsymbol{\xi}, -\boldsymbol{\eta}, +2\boldsymbol{\eta})\rangle + kT\mathbf{1}] \times (\mathbf{1} + \mathbf{N}\phi/f)^{-1} \quad (28)$$

is independent of coil rotation in flow because the flow field has no rotational component, $\Omega = 0$. The bilinear coordinate averages are derivable from the set of differential equations

$$\begin{aligned}
(1 + \dot{\gamma}\tau_p)\langle \xi_p^2\rangle - \nu_p/3\lambda_p &= -\tau_p'\ d\langle \xi_p^2\rangle/dt \\
(1 + \gamma\tau_p)\langle \xi_p\eta_p\rangle &= -\tau_p'\ d\langle \xi_p\eta_p\rangle/dt \\
(1 + \dot{\gamma}\tau_p)\langle \eta_p^2\rangle - \nu_p/3\lambda_p &= -\tau_p'\ d\langle \eta_p^2\rangle/dt \\
(1 - \gamma\tau_p/2)\langle \eta_p\zeta_p\rangle &= -\tau_p'\ d\langle \eta_p\zeta_p\rangle/dt \\
(1 - \dot{\gamma}\tau_p)\langle \zeta_p^2\rangle - \nu_p/3\lambda_p &= -\tau_p'\ d\langle \zeta_p^2\rangle/dt \\
(1 - \gamma\tau_p/2)\langle \zeta_p\xi_p\rangle &= -\tau_p'\ d\langle \zeta_p\xi_p\rangle/dt
\end{aligned} \quad (29)$$

Under consideration of the symmetry of flow field one obtains

$$\langle \xi_p^2\rangle = \langle \eta_p^2\rangle = \frac{1}{3\mu_p}\exp\{-[t + (\dot{\gamma}_0\tau_p/i\omega)e^{i\omega t}]/\tau_p'\} \times \int_0^{t/\tau'_p} \exp[x + (\dot{\gamma}_0\tau_p/i\omega\tau_p')e^{i\omega\tau'_p x}]\,dx$$

$$\langle \zeta_p^2\rangle = \frac{1}{3\mu_p}\exp\{-[t - 2(\dot{\gamma}_0\tau_p/i\omega)e^{i\omega t}]/\tau_p'\} \times \int_0^{t/\tau'_p} \exp[x - 2(\dot{\gamma}_0\tau_p/i\omega\tau_p')e^{i\omega\tau'_p x}]\,dx$$

$$\langle \xi_p\eta_p\rangle = \langle \eta_p\xi_p\rangle = \langle \xi_p\zeta_p\rangle = 0. \quad (30)$$

These averages still contain the transient which, in the general case, cannot be easily separated from the stationary solution reached after the transient has tapered off (fig. 7).

The separation can be performed if $\dot{\gamma}_0\tau_p/\omega\tau'_p$ is so small that one can replace the exponential function by its linear expansion. In such a case one obtains for the stationary solution

$$\langle \xi_p^2\rangle = \frac{1}{3\mu_p}\left(1 - \dot{\gamma}_0\tau_p\frac{e^{i\omega t}}{1 + i\omega\tau_p'}\right)$$

$$\langle \zeta_p^2\rangle = \frac{1}{3\mu_p}\left(1 + 2\dot{\gamma}_0\tau_p\frac{e^{i\omega t}}{1 + i\omega\tau_p'}\right) \quad (31)$$

The intrinsic Trouton viscosity turns out to be

$$\begin{aligned}
&[\eta]_{l\omega}^* \quad (32)\\
&= [\sigma_{33} - \sigma_{11}]^*/\gamma\eta_s \\
&= \frac{RT}{M\eta_s}\sum_{p=1}^{Z} 3\mu_p[\langle \zeta_p^2 - \xi_p^2\rangle/\dot{\gamma} + (\tau_p\nu_p\varphi_p/f)\langle 2\zeta_p^2 - \xi_p^2\rangle] \\
&= \frac{3RT}{M\eta_s}\sum_{p=1}^{Z}\left(\frac{\tau_p(1 - \omega\tau_p')}{1 + \omega^2\tau_p'^2} + \frac{\tau_p' - \tau_p}{3}\right) \\
&= \frac{3RT}{M\eta_s}(I/\omega + \sum_{p=1}^{Z}(\tau_p' - \tau_p)/3 - i\mathrm{II}/\omega).
\end{aligned}$$

The additional term $\sum(\tau_p' - \tau_p)/3$ is independent of ω and hence represents the Trouton viscosity in the second Newtonian range where I/ω and II/ω disappear. As in the case of conventional intrinsic viscosity, eq (20), the finite value at $\omega \to \infty$ is a consequence of internal viscosity, i.e., of partial coil rigidity. The frequency dependence of $[\eta]_\omega$ and phase angle $\delta_{l\eta}$ are plotted in figure 8 for $Z = 100$, $h^* = .4$, and $\varphi/f = 2$.

The intrinsic birefringence reads

$$[\Delta n]_{l\omega}^* = K\frac{RT}{M\eta_s\dot{\gamma}}\sum_{p=1}^{Z} 3\mu_p\langle \zeta_p^2 - \xi_p^2\rangle \quad (33)$$

which for small amplitude reduces to

$$[\Delta n]_{l\omega}^* = \frac{3KRT}{M\eta_s}\cdot\sum_{p=1}^{Z}\tau_p/(1 + i\omega\tau_p') = \frac{3KRT}{M\eta_{s\omega}}\cdot(\mathrm{I} - i\mathrm{II})$$

$$\tan\delta_{ln} = \mathrm{II}/\mathrm{I} \quad (34)$$

This expression differs from the streaming birefringence in an oscillating flow field eq (21), only in the factor 3. The nonproportionality between viscosity and birefringence is again the consequency of the additional internal viscosity term in eq (33).

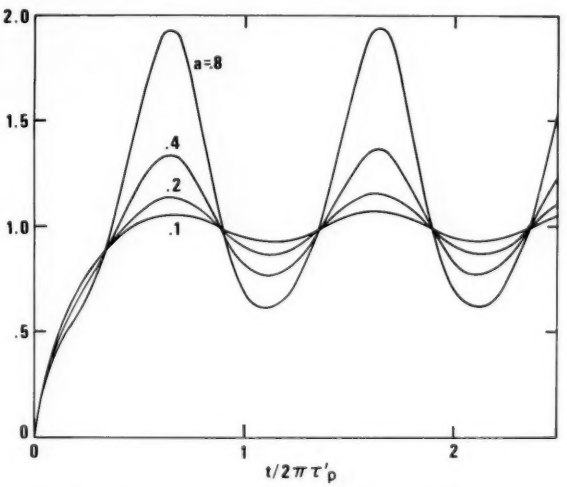

FIGURE 7. *Time dependence of* $\langle \xi_p^2\rangle = \langle \eta_p^2\rangle$ *according to eq (30) plotted versus* $t/2\pi\tau'_p$ *for the special case* $\varphi\tau'_p = 1$ *and* $a = \dot{\gamma}_0\tau_p/\omega\tau'_p$ *showing the short duration of transient effects and the rapid approach to the asymptotic periodic solution.*

The stabilization is slower for low $\omega\tau'_p$.

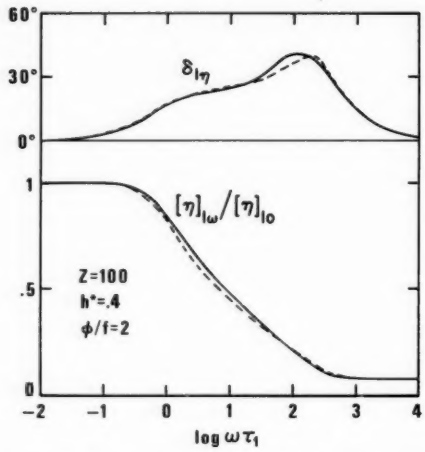

FIGURE 8. *Relative intrinsic Trouton viscosity* $[\eta]_{l\omega}/[\eta]_{l0}$ *and the phase angle* $\delta_{l\eta}$ *for* Z = 100, h* = .4, *and* $\varphi/f = 2$ *as function of* $\omega\tau_1$ *according to new (full line) and old (broken line) theory.*

Acoustic birefringence is in many respects closely related to birefringence in an oscillating jet flow. The main difference is the absence of lateral contraction as represented by $-\dot{\gamma}x/2$ and $-\dot{\gamma}y/2$. In contrast to jet flow with constant specific volume (incompressible liquid) the volume element subjected to an acoustic wave is periodically compressed and expanded. That means a constant $\langle \xi_p^2 \rangle$ yielding in eq (34) the replacement of the factor 3 by 2.

One has

$$[\Delta n]^*_{ac} = \lim_{c\to 0} \frac{\Delta n}{n c \mathrm{I}_{ac}^{1/2}}$$

$$= \frac{N}{M} K_{ac} \frac{\omega\tau}{(1+\omega^2\tau^2)^{1/2}} \sin\left[\omega(t - z_0/c_a) - \delta_{ac}\right]$$

$$= \frac{N}{M} \cdot K_{ac} \cdot \sum_{p=1}^{Z} \frac{-i\omega\tau_p}{1 + i\omega\tau_p'} e^{i\omega(t - z_0/c_a)}$$

$$= \frac{N}{M} K_{ac} (\mathrm{I} - i\mathrm{II}) e^{i\omega(t - z_0/c_a)}$$

$$\tan \delta_{ac} = \mathrm{II}/\mathrm{I}$$

$$K_{ac} = \frac{4\pi}{5}\left(\frac{n^2+2}{3n}\right)^2 \left(\frac{2}{\rho c^3 a c}\right)^{1/2} (\alpha_1 - \alpha_2)$$

$$\mathrm{I}_{ac} = \rho B^2 c_{ac}/2. \qquad (35)$$

Here z_0 is the location of the center of hydrodynamic resistance of the macromolecule, B is amplitude, I_{ac} is intensity and c_{ac} is propagation velocity of acoustic wave, and ρ is the density of solution. The frequency dependence of acoustic birefringence and phase angle is exactly the same as in the case of oscillating jet flow.

The difference between acoustic birefringence according to the correct new and the incorrect old values ν_p can be seen in figure 3 where $[\Delta n]_{ac}$ is plotted versus $\omega\tau_1$ for $Z = 100$, $h^* = .4$ and $\varphi/f = 2$. The phase angle δ_{ac} is identical with δ_n and δ_{ln}.

7. Conclusions

The paper presents the calculation of most of the intrinsic rheological and rheooptical effects of linear homopolymers in an oscillating flow field which may be explored experimentally. In the case of rheooptical effects only the intrinsic birefringence of the polymer is included. The form-birefringence is completely neglected. The same applies to the influence of large side groups which may effect independently the optical anisotropy of the segment and its frequency dependence.

The introduction of the appropriate $\nu_p = 1$ values instead of the old values $\nu_p = \lambda_{pZ}/\lambda_{pR}$ does not change drastically the effects depending on internal viscosity. As a rule the ratio between the new and old values of intrinsic viscosity, birefringence, and first normal stress difference is less than 2, at least in the range of Z between 3 and 300. With higher Z the differences increase as a linear function of log Z.

As already mentioned, the smallness of the difference is a consequence of the peculiar dependence of old $\nu^{p(1)}$ on p: much larger than 1 at small p and smaller than 1 at high p. Hence the larger contributions in the former part of the sums are partially compensated by the smaller contributions in the latter part.

The most important changes occur in the second Newtonian intrinsic viscosity which is the most conspicuous consequence of internal viscosity. Here the dependence of $[\eta]_\infty$ on Z is much less according to the new theory than it was in the case of the old theory.

No calculation of the gradient effects was attempted because one knows that in a flow with a finite velocity gradient the randomly coiled macromolecule is deformed with a consequent change of all interbead distances. This yields a change of interaction tensor **H** which leads to a modification of all eigenvalues λ_p. The rest values λ_p used in this paper are only applicable to effects where an extrapolation to zero gradient is straightforward. This is the case with dynamic effects where one uses very small gradients and concentrates on the frequency dependence of the effects measured. The situation, however, is basically different in the non-linear range of gradient dependence of excess stress and optical tensor.

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JOURNAL OF RESEARCH of the National Bureau of Standards—A. Physics and Chemistry
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Publications of the National Bureau of Standards*

J. Res. Nat. Bur. Stand. (U.S.), **80 A** *(Phys. and Chem.)*, No. 5 and 6 (September-December 1976), SD Catalog No. C13.22/sec.A:80/5-6.

Deviation of international practical temperatures from thermodynamic temperatures in the temperature range from 273.16 K to 730 K, L. A. Guildner and R. E. Edsinger.

Measurements of the specific heats, C_σ, and C_τ, of dense gaseous and liquid ethane, H. M. Roder.

Phase equilibria and crystal growth in the alkali antimonate systems Sb_2O_4-$NaSbO_3$, Sb_2O_4-$KSbO_3$, and Sb_2O_4-$NaSbO_3$-NaF, J. L. Waring, R. S. Roth, H. S. Parker, and W. S. Brower, Jr.

Vapor pressure formulation for water in range 0 to 100 °C. A revision, A. Waxler.

Revised lifetimes of energy levels in neutral iron, C. H. Corliss and J. L. Tech.

J. Res. Nat. Bur. Stand. (U.S.), **80 B** *(Math. Sci.)*, No. 4, (October-December 1976), SD Catalog No. C13.22/sec.B:80/4.

An inequality for doubly stochastic matrices, C. R. Johnson and R. B. Kellogg.

Improved error bounds for second-order differential equations with two turning points, F. W. J. Olver.

Pseudointersection graphs, P. J. Slater.

An efficient linear algebraic algorithm for the determination of isomorphism in pairs of undirected graphs, C. R. Johnson and F. T. Leighton.

Index to Volume 80B, January-December 1976.

Scaled equation of state parameters for gases in the critical region, J. M. H. L. Sengers, W. L. Greer, and J. V. Sengers, *J. Phys. Chem. Ref. Data* **5,** No. 1, 1-52 (1976).

Key words: air constituents; critical region parameters; ethylene; heavy noble gases; helium; linear model; methane; NBS equation; scaling laws; statistical analysis; steam; universality.

The anomalous thermodynamic behavior of fluids near the critical point can be described in terms of scaling laws. In this paper we consider two critical region equations of state, to be referred to as the NBS equation and the Linear Model parametric equation, that satisfy the scaling laws. A complete formulation of the thermodynamic properties in terms of the two equations is given. The statistical methods used for fitting these equations to experimental data are described. Each of the equations is fitted to experimental equation of state data for six fluids, namely He^3, He^4, Xe, CO_2, O_2, and H_2O. An evaluation of the recorded experimental material is included. We find that the two equations represent the experimental data in the range $|T-T_c|/T_c<0.03$ and $|\rho-\rho_c|/\rho_c<0.25$ equally well and that the exponents and amplitudes of the power laws deduced from the two equations agree closely. The optimum critical exponents appear to vary little from substance to substance. Moreover, a restricted version of the Linear Model with only two freely adjustable constants, in addition to the critical point parameters and the critical exponents, fits the data well in most cases, in agreement with expectations based on universality of critical behavior. The principle of universality is discussed and applied to predict critical region parameters for nine additional fluids, including several for which only limited experimental information is available. These additional fluids are Ar, Kr, N_2, H_2, CH_4, C_2H_4, SF_6, NH_3, and D_2O. We thus conclude with a single universal equation for the critical region of all fifteen fluids considered in this paper.

Microwave spectra of molecules of astrophysical interest. IX. Acetaldehyde, A. Bauder, F. J. Lovas, and D. R. Johnson, *J. Phys. Chem. Ref. Data* **5,** No. 1, 53-78 (1976).

Key words: acetaldehyde; internal rotation; interstellar molecules; microwave spectrum; radio astronomy; rotational transitions.

The microwave spectrum of acetaldehyde is critically reviewed and augmented through calculations which include the effects of internal rotation and centrifugal distortion. Since the primary objective of this review is to provide microwave spectral transitions applicable to radio astronomy studies, the review encompasses only the ground state rotational spectrum of the most abundant isotopic form of acetaldehyde, $^{12}CH_3{}^{12}CH^{16}O$. While all measured transitions are included, the predicted transition frequencies were limited to $J \leqq 12$ in the range of 900 MHz to 250 GHz. In addition to this spectral information, the review includes the rotational constants, centrifugal distortion constants, inertial rotation parameters, electric dipole moment, structural data, moments of inertia, and constants relating to the barrier to internal rotation.

Microwave spectra of molecules of astrophysical interest. X. Isocyanic acid, G. Winnewisser, W. H. Hocking, and M. C. L. Gerry, *J. Phys. Chem. Ref. Data* **5,** No. 1, 79-102 (1976).

Key words: isocyanic acid; interstellar molecules; microwave spectra; molecular parameters; rotational transitions; radio astronomy.

The available data on the microwave spectrum of isocyanic acid are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion parameters, dipole moments, hyperfine coupling constants, and structural parameters are tabulated. Detailed centrifugal distortion calculations have been carried out for all isotopic forms of this molecule, including DNCO. Transitions have been predicted for the parent molecule for the frequency range 160 MHz-300 GHz. All predicted transitions include error limits. The quoted uncertainties represent one standard deviation. A 95 percent confidence limit is ob-

**This listing includes recent NBS papers in the various NBS publication series—defined at end of the listing—as well as NBS-authored papers in non-NBS media—identified by 5-digit numbers. Publications with prices and SD catalog numbers may be purchased directly from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign: one-fourth additional). Microfiche copies of these GPO-published documents, as well as paper copy and microfiche versions of NBS Interagency Reports (NBSIR), may be purchased from the National Technical Information Service (NTIS), Springfield, Va. 22161. Reprints of papers in the NBS Journal of Research and non-NBS media, may often be obtained directly from the authors.*

tained by using approximately twice the calculated standard deviation. Estimated error limits for the measured transitions are discussed. References are given for all data included.

Diffusion in copper and copper alloys. Part IV. Diffusion in systems involving elements of group VIII, D. B. Butrymowicz, J. R. Manning, and M. E. Read, *J. Phys. Chem. Ref. Data* **5,** No. 1, 103-200 (1976).

Key words: alloys; cobalt; copper; diffusion; electromigration; iron; nickel; palladium; platinum; rhodium; ruthenium; thermomigration.

A survey, comparison, and critical analysis is presented of data compiled from the scientific literature concerning diffusion in copper alloy systems involving elements in Group VIII (Co, Fe, Ni, Pd, Pt, Rh, Ru). Here the term "copper alloy system" is interpreted in the broadest sense. For example, the review of diffusion in the Cu-M system reports all diffusion situations which involve both copper and element M, including diffusion of Cu in M or in any binary, ternary or multicomponent alloy containing M; diffusion of M in Cu or in any alloy containing Cu; and diffusion of any element in any alloy containing both Cu and M. Topics include volume diffusion, surface diffusion, grain boundary diffusion, tracer diffusion, alloy interdiffusion, electromigration, thermomigration, dislocation-pipe diffusion, and diffusion in molten metals. An extensive bibliography is presented along with figures, tabular presentation of data and discussion of results.

A critical review of the Stark widths and shifts of spectral lines from non-hydrogenic atoms, N. Konjevic and J. R. Roberts, *J. Phys. Chem. Ref. Data* **5,** No. 2, 209-258 (1976).

Key words: experimental; neutral atom; review; shift; Stark broadening; width.

A critical review of all available data on the Stark broadening and shifts of spectral lines of neutral elements has been undertaken. Over 200 papers compiled by the NBS Data Center on Atomic Line Shapes and Shifts have been evaluated, and of these, 68 were chosen as having reviewable data. Only those papers with properly determined critical factors, such as electron density, temperature, spatial homogeneity, optical depth, and instrument function deconvolution, were selected.

Experimental Stark widths and shifts for non-hydrogenic spectral lines of ionized atoms. (A critical review and tabulation of selected data), N. Konjevic and W. L. Wiese, *J. Phys. Chem. Ref. Data* **5,** No. 2, 259-308 (1976).

Key words: critically evaluated data; experimental; ionized spectra; Stark broadening parameters; Stark shifts; Stark widths.

A critical review of all available data on the Stark widths and shifts for lines of non-hydrogenic ionized spectra has been carried out. The relevant literature compiled by the NBS Data Center on Atomic Line Shapes and Shifts was critically evaluated, and from this evaluation 54 papers were found to satisfy all requirements and thus selected for this review. The most important factors determining the quality of plasma sources, diagnostic techniques, and line profile and shift determinations are discussed in detail in the first part of this review. In the second part the data tables containing the selected experimental Stark broadening parameters are presented. The data are arranged according to spectra and elements, and these are presented in alphabetical order. The accuracy of the experimental data is estimated on the basis of guidelines developed during the review, and comparisons with theoretical results are made whenever possible.

Atlas of the absorption spectrum of nitric oxide (NO) between 1420 and 1250 Å, E. Miescher and F. Alberti, *J. Phys. Chem. Ref. Data* **5,** No. 2, 309-318 (1976).

Key words: absorption spectrum; identification atlas; nitric oxide; Rydberg series.

This atlas presents the absorption spectrum between 1420 and 1250 Å of cold (−180 °C) nitric oxide gas, both $^{14}N^{16}O$ and $^{15}N^{16}O$, photographed in first order of a 10.5 m vacuum spectrograph. The spectral region comprises the Rydberg series (*s*-, *p*-, *d*-, and *f*-) of the molecule, including their limits of v=0, 1, and 2 of the ground state of the ion NO^+. In addition it shows some valence bands. To each band are assigned quantum numbers. The assignment is based on the detailed study of the fine structure of the bands, measured on spectral plates obtained in high order of the same instrument. Accurate numerical results of these measurements are tabulated for 140 molecular levels. A short survey on the NO absorption spectrum is given.

Ideal gas thermodynamic properties of propanone and 2-butanone, J. Chao and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* **5,** No. 2, 319-328 (1976).

Key words: enthalpy; entropy; equilibrium constant of formation; Gibbs energy of formation; heat capacity; ideal gas thermodynamic properties; internal rotational barrier height; propanone (acetone); torsional frequencies; 2-butanone (methyl ethyl ketone).

The ideal gas thermodynamic properties ($C_p°$, $S°$, $H°-H_0°$, $(H°-H_0°)/T$, $-(G'-H_0°)/T$, $\Delta Hf°$, $\Delta Gf°$, and log Kf) for propanone and 2-butanone in the temperature range from 0 to 1500 K and at 1 atm were calculated by statistical mechanical procedures, using rigid-rotor and harmonic-oscillator approximations. The internal rotation contributions to thermodynamic properties were evaluated by use of a partition function formed by summation of internal rotation energy levels. The calculated heat capacities and entropies are in agreement with the available experimental values.

Refractive index of alkali halides and its wavelength and temperature derivatives, H. H. Li, *J. Phys. Chem. Data* **5,** No. 2, 329-528 (1976).

Key words: alkali halides; optical constants; refractive index; temperature coefficient of refractive index.

Refractive index data for 20 alkali halides are exhaustively surveyed, compiled, and analyzed. The most probable values at 293 K for the transparent region are generated for the materials for which experimental data are sufficiently abundant and reliable. Provisional values are also provided for the wavelength regions where available data are insufficient or missing. Reasonable estimations of refractive index for the very scantily measured materials were made by incorporating the dielectric constants and wavelengths of absorption peaks into a simplified dispersion equation. Temperature derivatives of refractive index for most of the alkali halides were unavailable. However, using the existing data for the five most commonly used alkali halides, novel empirical facts were discovered and dn/dT formulas were constructed for all of the alkali halides. The calculated dn/dT values agree remarkably well with the existing experimental data.

Tables of critically evaluated oscillator strengths for the lithium isoelectronic sequence, G. A. Martin and W. L. Wiese, *J. Phys. Chem. Ref. Data* **5,** No. 3, 537-570 (1976).

Key words: *f*-values; isoelectronic sequence; lithium sequence; oscillator strengths; relativistic effects; spectral series; systematic trends.

Oscillator strengths for the lithium isoelectronic sequence have been critically evaluated and compiled by means of a new generalized analysis which makes use of several types of systematic trends and fundamental spectroscopic constraints. Relativistic effects have also been considered. The data are presented in separate tables for each ion of the sequence from Li I through Ni XXVI, and are arranged

within each table according to spectral series. Separate tables are presented for the $2s$-$2p$ and $2s$-$3p$ transitions, with both relativistic and nonrelativistic f-values listed for all ions of the sequence through Ni XXVI, as well as for a few selected ions of higher nuclear charge. The general tables contain transitions of the type *ms-np*, *mp-ns*, and *mp-nd*, with $2 \leq m \leq 4$ (m is the lower principal quantum number) and $3 \leq n \leq 7$. Since most recommended data were determined from a nonrelativistic analysis, hydrogenic relativistic considerations were applied to estimate when the data would be significantly altered by the inclusion of relativistic effects, and such f-values were excluded from the tabulation.

Ideal gas thermodynamic properties of six chlorofluoromethanes, S. S. Chen, R. C. Wilhoit, and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* **5,** No. 3, 571-580 (1976).

Key words: chlorofluoromethanes; ideal gas thermodynamic functions; principal moments of inertia; standard enthalpy of formation; vibrational fundamentals.

Spectroscopic and thermal data were reviewed. The selected values for the principal moments of inertia, the vibrational fundamentals, and the standard enthalpy of formation at 298.15 K for each of the six chlorofluoromethanes were used to derive the chemical thermodynamic properties of molecules from 0 to 1500 K, based on the rigid-rotor harmonic-oscillator approximation. The calculated values are in accord with experimental heat capacities and entropies.

Survey of superconductive materials and critical evaluation of selected properties, B. W. Roberts, *J. Phys. Chem. Ref. Data* **5,** No. 3, 581-822 (1976).

Key words: bibliography; composition; critical fields; critical temperature; crystallographic data; low temperature; superconductive materials; superconductivity.

This publication includes all data on superconductive materials intercepted through March 1975. Data on the bulk elements have been critically evaluated, and values on alloys, compounds, and other forms have been selected and condensed to indicate the probable value and spread of values observed. Proven nonsuperconductors have been noted. Conflict in data values has been noted. All data have been keyed to the literature in one or more of the tables. Special subdivisions are presented for superconductive materials with organic constituents and for those based on semiconductive materials. The properties presented are superconductive critical temperature, critical magnetic fields, material state and composition including crystal-structure type where noted, a key to thin-film forms, and the presence of thermodynamic data (generally the electronic specific heat, γ, and Debye θ). High-magnetic-field superconductors are noted with listing of H_{c1}, H_c, H_{c2}, and H_{c3} plus the temperature of observation T_{obs}.

Nuclear spins and moments, G. H. Fuller, *J. Phys. Chem. Ref. Data* **5,** No. 4, 835-1092 (1976).

Key words: evaluated data; nuclear electric hexadecapole moments; nuclear electric quadrupole moments; nuclear magnetic dipole moments; nuclear magnetic octupole moments; nuclear spins.

A summary of nuclear-moment values and an index, arranged by Z and A, is presented. The summary value is based on the experimentally determined values of the nuclear moments which have been listed in tables according to the techniques used. Each table is preceded by a short introduction describing the experimental technique involved and the method of calculating the moment from the measured quantities. References are given for all data quoted. The date for the last systematic literature search is included with each table. This tabulation supplements and revises the earlier tables which appeared in Nuclear Data Tables, Volume A5, 433-612 (1969).

Nuclear moments and moment ratios as determined by Mössbauer spectroscopy, J. G. Stevens and B. D. Dunlap, *J. Phys. Chem. Ref. Data* **5,** No. 4, 1093-1122 (1976).

Key words: Mössbauer; nuclear electric quadrupole moments; nuclear magnetic dipole moments.

Values are given for Mössbauer effect measurements of nuclear magnetic moments, spectroscopic quadrupole moments, ratios of moments between low lying excited states and the ground state of the same isotope, and ratios of moments between states of different isotopes. Adopted values for moments, obtained by direct selection of specific results or by an averaging process, are presented. The literature has been covered through December 1974.

Rate coefficients for ion-molecule reactions I. Ions containing C and H, L. W. Sieck and S. G. Lias, *J. Phys. Chem. Ref. Data* **5,** No. 4, 1123-1146 (1976).

Key words: chemical kinetics; data evaluation; gas phase; hydrocarbons; ion-molecule reactions; mass spectrometry; rate coefficients.

A compilation is presented of experimentally determined bimolecular and third order rate coefficients for the reactions of hydrocarbon ions with neutral molecules in the vapor phase. The literature covered is from 1960 to the present, and both positive and negative ions are considered. Four hundred and fifty-eight separate reaction-pairs are tabulated, and the ionic reaction products and experimental conditions are specified wherever possible. Preferred values are suggested for a number of these processes.

Microwave spectra of molecules of astrophysical interest. XI. Silicon Sulfide, E. Tiemann, *J. Phys. Chem. Ref. Data* **5,** No. 4, 1147-1156 (1976).

Key words: interstellar molecules; microwave spectra; radio astronomy; rotational transitions; silicon sulfide; spectra.

The available data on the microwave spectrum of silicon sulfide are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, electric dipole moment and hyperfine coupling constant are tabulated. Observed rotational transitions are presented for all measured isotopic forms of SiS. These data have been analyzed in order to predict rotational transition of the ground vibrational state up to 300 GHz. From the given rotational constants transition frequencies in excited vibrational states can be calculated with little loss in accuracy.

Error limits have been taken from the original literature for each measured frequency. The predicted transition frequencies are given with uncertainties which represent the 90 percent confidence limit.

Monogr. 151. **Automatic measurement of network parameters—A survey,** R. W. Beatty, *Nat. Bur. Stand. (U.S.), Monogr. 151,* 113 pages (June 1976) SD Catalog No. C13.44:151, $4.50.

Key words: automatic network analyzers; computer-controlled measurement; magic tee; microwave measurement methods; multiple probe devices; reflectometers; rotating probe devices; slotted lines; survey of automatic techniques; swept frequency measurements; Wheatstone Bridge.

A survey is made of principles, methods, and systems developed for semiautomatic and automatic measurement of network parameters, such as the complex scattering coefficients, impedance, VSWR, return loss, attenuation, and group delay time. The period covered is from 1922 to 1975 and developments range from simple ideas such as a motor driven probe for a slotted line, to computer-controlled transmission and reflection measurement systems.

The essential ideas and features of each development are briefly described and both similarities and differences between various schemes are pointed out. Trends in modern developments are noted

and some of the options open for future work are mentioned. A bibliography of 151 references is included.

Monogr. 153. **The first spectrum of hafnium (Hf I),** W. F. Meggers and C. E. Moore, *Nat. Bur. Stand. (U.S.), Monogr. 153,* 117 pages (July 1976) SD Catalog No. C13.44:153, $1.35.

Key words: analysis, Hf I spectrum; hafnium, analysis of first spectrum; spectrum, Hf I; Zeeman effect, Hf I.

The present publication terminates the work on the analysis of Hf I which was started by the late W. F. Meggers in 1928 and left unfinished in 1966. His final line list contains some 4700 lines of which about 67 percent have been classified. Observed g-values are known for 198 levels. The reliability of the Zeeman observations is indicated in tables containing sums of Observed and Landé g-values for selected groups of "even" and "odd" terms.

An attempt has been made to continue Meggers' analysis in LS-coupling as far as possible. This coupling is not rigorous in Hf I, and many intervals are irregular. Consequently, the levels are given also in numerical order with the even and odd levels presented in separate tables.

An ionization limit of 54700 ± 600 cm^{-1}, giving an ionization potential of 6.78 ± 0.07 eV has been derived from a two-member series.

The long line lists are given in two Appendices: Appendix A contains the observed Zeeman data for the individual lines, 531 in all; Appendix B consists of the complete line list of observed and classified lines.

By far the greater part of the analysis is that of Meggers. Detailed notes explain changes that have been introduced and additions to this work.

Monogr. 154. **The dynamics of fields of higher spin,** R. W. Hayward, *Nat. Bur. Stand. (U.S.), Monogr. 154,* 99 pages (Aug. 1976) SD Catalog No. C13.44:154, $1.70.

Key words: causality; high spin fields; inhomogeneous Lorentz group; relativistic fields; wave equations.

There are several difficulties that plague all existing relativistic equations of motion describing elementary fields having an intrinsic spin greater than one. While the free field equations can be shown to be explicitly covariant, the introduction of interactions gives rise to a phenomenon of noncausality. In the presence of interactions, the retarded solutions spread beyond the light cone and the influence travels faster than light. Furthermore, the solutions in certain simple potentials do not have a finite norm, violating the probabilistic requirements of quantum mechanics.

This paper develops a relativistic theory that is free of the aforementioned difficulties. This Lagrangian theory describes fields and particles with arbitrary mass and charge and having any discrete spin, integer or half integer. Apart from gauge conditions there are no subsidiary conditions.

A matrix formulation is used. The generators of the inhomogeneous Lorentz group for a field of any intrinsic spin and mass are defined in terms of Wigner operators of the group SU(2) and a metric operator. A maximal Abelian set of invariants is formed which defines two completely reducible representation bases of the inhomogeneous Lorentz group having distinct structures. A set of γ matrices, obeying a Clifford algebra, is also defined in terms of the Wigner operators and the metric operator. State vectors having different structures and Lorentz transformation properties can be related to one another by operators involving the γ matrices.

The equations of motion can be obtained from the Lagrangian by variational methods, and certain aspects of the canonical formalism can be used to quantize the fields. Invariance of the Lagrangian under infinitesimal displacements and rotations yield conservation laws and constants of the motion for pertinent physical observables. The metric of the Hilbert space of the states is uniquely defined for any spin field, assuring positive definite four momenta and charge.

The Dirac formulation for the spin one-half field and the Maxwell-Lorentz formulation for the electromagnetic field are special cases of this theory.

Monogr. 157. **Computers, health records, and citizen rights,** A. F. Westin, *Nat. Bur. Stand. (U.S.), Monogr. 157,* 401 pages (Dec. 1976) SD Catalog No. C13.44:157, $4.55.

Key words: citizen rights; computers; confidentiality; data systems; health records; information policy; management principles; medical records; privacy; recordkeeping practices; security.

This report investigates the impact of computers on citizen rights in the health recordkeeping area. Under Dr. Alan F. Westin's direction, from July of 1974 to April of 197[illegible], a small interdisciplinary team did the following: (1) examined published literature from medicine and health, law, computing, and social science; (2) conducted interviews with major computer manufacturers, systems developers, health professionals and civil liberties, public interest, consumer, and minority-rights groups; (3) made on-site visits to six representative health-care organizations using computers to handle personal records; (4) corresponded with 70 organizations in the health field; and (5) subjected an initial draft report to review by a conference of experts in September 1975 and subsequently by about 50 outside reviewers. The findings of this investigation were then combined into this four-part report. Part One describes the world of medical data and citizen rights within the framework of three zones—primary health care (by health professionals), service payers and health care reviewers, and social uses of health data (such as in employment, life insurance, and welfare); Part Two treats patterns of computerization in health-care organizations that were studied in depth; and Part Four analyzes the impact of computerization on personal health records, presentscomparisons with six other democratic nations, and states 12 recommended management principles for health care data systems. The report also contains a 28 page bibliography and twelve appendices with support documents and information.

H119. **Quieting: A practical guide to noise control,** R. D. Berendt, E. L. R. Corliss, and M. S. Ojalvo, *Nat. Bur. Stand. (U.S.), Handb. 119,* 163 pages (July 1976) SD Catalog No. C13.11:119, $5.10.

Key words: airborne and structure-borne sounds; aircraft noise intrusion; annoyance; appliance noise; health and hearing hazards; household noise; legal and community action; loudness; noise control and abatement; traffic noise.

This guide offers practical solutions for ordinary noise problems that a person is likely to meet. The discussion describes the ways in which sounds are generated, travel to the listener, and affect his hearing and well-being. Recommendations are given for controlling noise at the source and along its path of travel, and for protecting the listener. The guide instructs the reader by way of "Warning Signs" on how to determine whether he is being subjected in his environment to prolonged noise exposures that may prove hazardous to his hearing. Remedies are given for noise problems that a person is likely to find in his home, at work and at school, while traveling, and in the growth and development of his community. The remedies include noise prevention techniques and selection of quiet alternatives to existing noise sources. General principles for selecting quiet appliances are given. Ways of searching for the sources of noise and for determining the paths over which they travel to the listener are described. A detailed index is given for individual noise sources describing specific solutions to the problems they present. General ways of looking for inherently quiet homes and travel accomodations are described. In a final chapter, there are suggestions for enlisting com-

munity help where large external sources of noise must be quieted, such as those arising from public utilities and public transportation.

H120. **Energy management guide for light industry and commerce,** W. J. Kelnhofer and L. A. Wood, *Nat. Bur. Stand. (U.S.), Handb. 120,* 28 pages (Dec. 1976) SD Catalog No. C13.11:120, $0.70.

Key words: energy conservation; energy conservation guide; energy conservation opportunities; energy conservation program; industrial energy conservation.

The Energy Management Guide for Light Industry and Commerce is a training tool to assist small industrial and commercial organizations in an energy conservation program. It is part of a planned series, starting with NBS HB-115 (EPIC), of guides and training aids to assist industry in making the most efficient use of the energy supply.

While much of the information in the Light Industry Guide has been published in EPIC, the material has been edited and rewritten in shortened form for use by the large number of small organizations with a limited supply of technical manpower. The energy conservation case studies (Cost Saving Opportunities) have been written with this target audience in mind.

SP384. **Annotated bibliography of the literature on resource sharing computer networks. Revised 1976,** H. M. Wood, S. W. Watkins, and I. W. Cotton, *Nat. Bur. Stand. (U.S.), Spec. Publ. 384 (revised),* 179 pages (Sept. 1976) SD Catalog No. C13.10:384/rev., $2.45.

Key words: bibliography; computer network; data communications; resource sharing.

This bibliography consists of over 1,000 references with critical annotations to the literature on computer networks. A classification scheme has been developed to make each citation more accessible by general topic. Five indexes to the bibliography are included: author index, corporate author index, network index, title word index, and report number index.

SP396-4. **Critical surveys of data sources: Electrical and magnetic properties of metals,** M. J. Carr, R. B. Gavert, R. L. Moore, H. W. Wawrousek, and J. H. Westbrook, *Nat. Bur. Stand. (U.S.), Spec. Publ. 396-4,* 92 pages (July 1976) SD Catalog No. C13.10:396-4, $1.55.

Key words: commercial alloys; data sources; electrical properties; magnetic properties; metals.

This survey is intended to provide a directory of authoritative sources of numerical data on the electrical and magnetic properties of metals, with emphasis on commercial alloys. Fifty-nine sources, including handbooks and other publications, information centers, trade associations, and technical societies are described in detail, including information on the properties and materials covered and the criteria used in the selection of data. A few additional related publications are listed with brief descriptions.

SP400-15. **Semiconductor measurement technology: ARPA/NBS workshop III. Test patterns for integrated circuits,** H. A. Schafft, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-15,* 52 pages (Jan. 1976) SD Catalog No. C13.10:400-15, $1.50.

Key words: data acquisition; data display; integrated circuits; measurement technology; microelectronics; process control; reliability; semiconductors; silicon; test patterns.

Synopses are presented of talks and discussion periods at a meeting on the use and development of MOS and bipolar test patterns and associated data acquisition systems. The discussions revealed that device manufacturers and users are making increased use of test patterns as powerful new measurement tools that can electrically monitor various process parameters to aid in the control of materials, wafer processes, circuit performance, and reliability. However, the large volume of data generated from these test patterns and therequirement for rapid diagnostic feedback present severe challenges in data management and display. In this report several data acquisition systems are described, as are approaches for presenting data in more easily interpretable graphic displays. The need for improvements in the design of test patterns is emphasized. In particular, problems with measuring contact resistance and the properties of oxides, surfaces, and defects, are identified. Numerous test structures are described including charge coupled device structures whichcan measure some characteristics not easily measured by other means. Also described are NBS's efforts and plans to identify, analyze, and intercompare selected test structures of value to the industry and its customers, and to develop measurement methods for use with these structures.

SP400-25. **Semiconductor measurement technology. Progress Report, July 1 to December 31, 1975,** W. M. Bullis, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-25,* 87 pages (Oct. 1976) SD Catalog No. C13.10:400-25, $1.45.

Key words: acoustic emission; Auger electron spectroscopy; beam-lead bonds; bias-temperature stress test; boron redistribution; capacitance-voltage methods; dopant profiles; electrical properties; electronics; four-probe method; hermeticity; interface states; ion implantation; ion microprobe mass analysis; leak tests; measurement methods; microelectronics; moisture infusion; optical flying-spot scanner; passivation overcoats; photoresist; pull test; resistivity; scanning acoustic microscope; scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control: silicon; silicon dioxide: silicon on sapphire; spreading resistance; test patterns; thermally stimulated current; thermal resistance; ultrasonic wire bonding; voltage contrast mode; x-ray photoelectron spectroscopy.

This progress report describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Both in-house and contract efforts are included. The emphasis is on silicon device technologies. Principal accomplishments during this reporting period included (1) preliminary results of a systematic study of the effects of surface preparation on spreading resistance measurements; (2) development of an optical test for surface quality of sapphire; (3) development of a basis for an exposure sensitivity specification for photoresists; and (4) development of a modular cell concept for test structure design and layout. Also reported are the results of work on four-probe resistivity measurements, comparison of techniques for surface analysis, ion microprobe mass analysis, analysis of process chemicals with flame emission spectrometry, redistribution profiles, thermally stimulated current response of interface states, bias-temperature stress test measurements on MOS capacitors, a high voltage capacitance-voltage method for measuring characteristics of thick insulator films, hydrogen chloride oxidation, ion implantation parameters, methods for determining integrity of passivation overcoats, measurement of free sodium in an oxidation furnace by resonance fluorescence, a square array collector resistor test structure, an electrical alignment test structure, two dimensional wafer maps, test pattern design and analysis for silicon-on-sapphire MOS device technologies, a nondestructive acoustic emission test for beam-lead bonds, wire bond pull test, bondability of doped aluminum metallizations, leakage into double hermetic enclosures, a static expansion dry gas gross leak test, correlation of moisture infusion in semiconductor packages with leak size and device reliability, an automated scanning low-energy electron probe, an optical flying-spot scanner, scanning electron microscopy, scanning acoustic microscopy, and thermal resistance measurements on power transistors and simple integrated circuits. Supplementary data concerning staff, publications, workshops and symposia, standards committee activities, and technical services are also included as appendices.

SP400-34. **Semiconductor measurement technology: Safe operation of capacitance meters using high applied-bias voltage,** A. M. Goodman, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-34,* 57 pages (Dec. 1976) SD Catalog No. C13.10:400-34, $1.45.

Key words: bias-isolation unit; capacitance measurements at high applied-bias voltage; capacitance-meter; extended-range capacitance measurement; high-voltage C(V) measurements; modified MIS C(V) measurements.

The use of capacitance meters (C-meters) to determine small-signal (differential) capacitance at 1 MHz as a function of applied-bias voltage is widespread. The maximum value of the bias voltage which may be applied to a sample under test with any commercially available C-meter is 600 V or less. A larger bias-voltage capability is required for certain applications.

This report describes a technique for using a commercial C-meter with a Bias-Isolation Unit (BIU) for capacitance measurements at bias-voltage magnitudes up to 10 kV without damage to the measurement equipment. The basic principles of operation and the details of the electrical design of a BIU are discussed.

The use of the BIU imposes certain limitations on the range of sample capacitance which may be measured without introducing excessive error. The theory of these limitations is presented and compared with experimental results obtained from the use of the BIU with each of three commercially available C-meters. The measurement capability demonstrated by these results appears to be adequate for all current and future applications. For less than ± 1 percent error in the indicated (measured) capacitance, the measurable range of the sample capacitance is found to be from 0 to at least 400 pF. In some applications, it is important to be able to accurately measure small changes in the sample capacitance; for less than ± 1 percent error in the indicated (measured) value of a small change in the sample capacitance, the measurable range of the sample capacitance is found to be from 0 to at least 130 pF.

Construction details of the BIU are appended.

SP403. **Energy conservation through effective energy utilization.** 1973 Engineering Foundation Conference, New England College, Henniker, NH, Aug. 19-24, 1973, J. C. Denton, S. Webber, and J. Moriarty, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 403,* 251 pages (June 1976) SD Catalog No. C13.10:403, $3.30.

Key words: automobile; break-even analysis; conservation; cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics.

These proceedings of the 1973 Engineering Foundation Conference focus on effective utilization of thermal energy as a means of energy conservation. It is hoped publication will help stimulate the national dialogue toward a balanced national program for more energy conservation.

The varied professional backgrounds of the participants provided an interdisciplinary approach for action steps to be taken in areas where research is needed and will provide a significant impact. For example, the development of better stack controls was recommended as a specific research task, and the improvement of energy accounting systems and energy use norms was recommended as a useful research area. Broad agreement was reached that there is much left to be accomplished in thermal process technology as used in industrial processes, in industrial equipment, and in heating, ventilating, and air conditioning (HVAC) equipment for buildings.

A clear conclusion of the conference is that while new technology is important the introduction of much technology that is already available is equally, if not more, important. Institutional barriers relating to economics, management, finance, and national policy keep available technology standing in the wings. The conference papers and discussions show that engineering design, when it can be rigorously applied, does result in striking reductions in energy use in the thermal process technologies.

SP422. Volume I and II. **Accuracy in trace analysis: Sampling, sample handling, analysis.** Proceedings of the 7th Materials Research Symposium held at the National Bureau of Standards, Gaithersburg, MD, Oct. 7-11, 1974, P. D. LaFleur, Ed., *Nat. Bur. Stand. (U.S.), Spec. Pub. 422, Vol. I,* 645 pages, *Vol. II,* 636 pages, (Aug. 1976) SD Catalog No. C13.10:422/vol. I and II, $20 per 2-part set.

Key words: accuracy; analysis; analytical chemistry; sample handling; sampling; trace analysis.

This book is the formal report of the proceedings of the 7th Materials Research Symposium: Accuracy in Trace Analysis. This volume contains the invited and contributed papers presented at the Symposium, and which treat problems of sampling and sample handling as well as the usually-discussed analytical methodology. Many important techniques and methods are described, and extensive references are presented, to give deeper insight into the problems of obtaining accurate results in trace analytical chemistry. Accordingly, this volume should not only stimulate greater interest in research in these areas but should provide a valuable guide for everyday analytical problems.

SP433. **MFPG—Success by design: Progress through failure analysis.** Proceedings of the 21st Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Gaithersburg, MD, Nov. 7-8, 1974, T. R. Shives and W. A. Willard, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 433,* 229 pages (July 1976) SD Catalog No. C13.10:433, $3.50.

Key words: design; engineering education; failure analysis; failure analysis case histories; failure prevention; reliability; safety.

These Proceedings consist of a group of twenty-two submitted papers and discussions from the 21st meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards in Gaithersburg, Maryland on November 7-8, 1974. The central theme of the Proceedings was improvement in design through failure analysis. Emphasis was on design philosophy, the use of failure analysis case studies as an educational tool, successful redesign through failure analysis, and design oversights.

SP447. **Weights and measures standards of the United States—A brief history,** L. V. Judson, *Nat. Bur. Stand. (U.S.), Spec. Publ. 447,* 44 pages (Mar. 1976) SD Catalog No. C13.10:447, $1.00.

Key words: history of measurement standards; measures; metric system; standards; units of measurement; weights.

Two publications of the National Bureau of Standards, now out of print, that deal with weights and measures have had widespread use and are still in demand. The publications are NBS Circular 593, The Federal Basis for Weights and Measures (1958), by Ralph W. Smith, and NBS Miscellaneous Publication 247, Weights and Measures Standards of the United States—A Brief History (1963), by Lewis V. Judson.

To meet the current demand for information on the history of weights and measures in the United States, Miscellaneous Publication 247, referred to above, updated where needed to bring it into accord with current usage, is reprinted in this publication, together with a brief addendum that discusses important events involving weights and measures of the period 1963-1975. NBS Circular 593 is not being reprinted because of the significant overlap of material treated in the two publications.

SP448. **Automation technology applied to public service.**

Proceedings of a Conference on Automation Technology Applied to Public Service, held at the National Bureau of Standards, Gaithersburg, MD, May 21-22, 1974, E. G. Johnsen, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 448*, 87 pages (Sept. 1976) SD Catalog No. C13.10:448, $1.90.

Key words: automation technology; economic impact of automation; productivity improvement; public services; social impact of automation.

The Conference on Automation Technology Applied to Public Service, held in May 1974, was cosponsored by the National Bureau of Standards, the General Accounting Office, the National Science Foundation and the Urban Institute. The objectives of the conference were first, to explore the use of automation technology as a means of increasing the efficiency of Government in providing higher quality public services at lower cost; and second, to explore the political, social and economic aspects involved in managing the public service applications of automation. Potential uses of automation technology discussed include automating operations in environments hazardous to safety and health of people, such as fire fighting, and the automation of services that are tedious, boring or demeaning for people to do. The spectrum of potential applications of automation technology in public service ranges from garbage collection to aids to the handicapped and from water treatment process control to the adaptive computerized regulation of traffic in urban areas. Some participants warn that the way in which automation technology is applied must be carefully thought out and supervised in order to minimize disruptive economic and social effects.

SP449. **Chemical kinetics of the gas phase combustion of fuels. (A Bibliography on the Rates and Mechanisms of Oxidation of Aliphatic C_1 to C_{10} Hydrocarbons and of Their Oxygenated Derivatives),** F. Westley, *Nat. Bur. Stand. (U.S.), Spec. Publ. 449*, 138 pages (Oct. 1976) SD Catalog No. C13.10:449, $2.00.

Key words: bibliography; chemical kinetics; combustion; free radicals; gas phase; hydrocarbons; oxidation; oxygen; oxygenated organic compounds; ozone.

A reaction oriented list of references is provided for papers and reports containing rate data for gas phase reactions of combustion and oxidation of aliphatic saturated or unsaturated C_1 to C_{10} hydrocarbons, alcohols, aldehydes, ketones, ethers, peroxides and their free radicals. The list also includes decomposition, disproportionation, atom transfer and recombination reactions of the oxygen containing species noted above. Pyrolytic reactions of hydrocarbons and their radicals are excluded. All the processes listed here have been reported to occur in the gas phase combustion of fuels. In addition, a list of critical reviews dealing with the reaction kinetics of the above processes and a list of papers dealing with generalized mechanisms of the same reactions are also included. More than 800 papers covering 540 reactions are listed. The period covered extends from 1902 through June 1975.

SP451. **Data base directions. The next steps.** Proceedings of the Workshop of the National Bureau of Standards and the Association for Computing Machinery, held at Fort Lauderdale, FL, Oct. 29-31, 1975, J. L. Berg, Ed., R. G. Canning, D. L. Adams, R. W. Bemer, G. Dodd, R. M. Gall, and C. D. Trigg, *Nat. Bur. Stand. (U.S.), Spec. Publ. 451*, 175 pages (Sept. 1976) SD Catalog No. C13.10:451, $2.40.

Key words: auditing; cost/benefit analysis; data base; data base management; DBMS; government regulation; management objectives; privacy; security; standards; technology assessment; user experience.

What information about data base technology does a manager need to make prudent decisions about using this new technology? To provide this information the National Bureau of Standards and the Association for Computing Machinery established a workshop of approximately 80 experts in five major subject areas. The five subject areas were auditing, evolving technology, government regulations, standards, and user experience. Each area prepared a report contained in these proceedings. The proceedings provide guidance on steps managers should follow to prepare themselves and their organization for the installation of data base management concepts. The auditing working panel noted the increased vulnerability of organizations who integrate their formerly dispersed and redundant files into a data base and suggest actions to address this risk. The technology report noted several promising parallel developments but concluded that the future would see evolving, rather than revolutionary data base progress. Government regulations, particularly the drive for individual privacy rights, were seen to play an important role in determining data base directions and the panel's guidance on cost impact suggest that organizations would experience reduced costs with data base technology. Standards pervaded all issues and were found necessary in several sub-areas of data base technology but the panel saw no immediate likelihood of national data base standards. The user experience working panel noted that data base systems had impacted their organizations to the extent of reconsidering existing data flows, areas of responsibilities, and procedures.

SP452. **MFPG—The role of coatings in the prevention of mechanical failures.** Proceedings of the 23d Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Gaithersburg, MD, Oct. 29-31, 1975, T. R. Shives and W. A. Willard, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 452*, 199 pages (Sept. 1976) SD Catalog No. C13.10:452, $2.65.

Key words: barrier film; chemical coatings; failure prevention; mechanical failure; metal coatings; plated coatings; polymer coatings; solid film lubricants; sputtered coatings; wear.

These Proceedings consist of a group of eighteen submitted papers and discussion from the 23d Meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards in Gaithersburg, Maryland on October 29-31, 1975. The central theme of the Proceedings is the Role of Coatings in the Prevention of Mechanical Failures, with emphasis on polymer coatings, metal coatings, solid film lubricants, and chemical coatings.

SP453. **Ultrasonic tissue characterization.** Proceedings of a Seminar held at the National Bureau of Standards, Gaithersburg, MD, May 28-30, 1975, M. Linzer, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 453*, 274 pages (Oct. 1976) SD Catalog No. C13.10:453, $3.55.

Key words: absorption; acoustic; A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; tissue parameters, tissue signature; tumor; ultrasonic spectroscopy; ultrasound; velocity.

An international Seminar on Ultrasonic Tissue Characterization was held at the National Bureau of Standards on May 28-30, 1975. The meeting was cosponsored by the National Bureau of Standards, the National Science Foundation and the National Institutes of Health. This volume contains extended versions of 20 of the 21 talks presented at the Seminar. Topics covered include techniques for measurement of ultrasonic tissue parameters, the dependence of tissue properties on physical and biological variables (*e.g.*, ultrasonic frequency, temperature) and pattern recognition techniques.

SP454. **An annotated bibliography of compiled thermodynamic data sources for biochemical and aqueous systems (1930 to 1975). Equilibrium, enthalpy, heat capacity, and entropy data,** G. T. Armstrong and R. N. Goldberg, *Nat. Bur. Stand. (U.S.), Spec. Publ. 454*, 67 pages (Sept. 1976) SD Catalog No. C13.10:454, $1.65.

Key words: aqueous systems; bibliography; biochemical

systems; enthalpy data; entropy data; equilibrium data; Gibbs energy data; heat capacity data; partial molal properties; thermochemistry; thermodynamics; review articles; water pollution.

Contained herein is a selected and annotated bibliography of sources of compiled and evaluated chemical thermodynamic data relevant to biochemical and aqueous systems. The principal thermodynamic properties considered herein are Gibbs energy and equilibrium data, enthalpies of formation and reaction, heat capacities and entropies, and the corresponding partial molal properties. Derived quantities used in calculating the above are also included. Transport and mechanical data have also been identified to a lesser degree. Included in the annotations to the data sources are brief descriptions of the types of properties tabulated, the classes of materials dealt with, and the degree of completeness of the compilations.

SP455. **Electrocatalysis on non-metallic surfaces.** Proceedings of a workshop held at the National Bureau of Standards, Gaithersburg, MD, Dec. 9-12, 1975, A. D. Franklin, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 455*, 372 pages (Nov. 1976) SD Catalog No. C13.10:455, $4.45.

Key words: catalysis; characterization; chemisorption; electrocatalysis; electrochemistry; electrode processes; nonmetals; photoelectrolysis; solid electrolytes; surfaces.

This book presents the proceedings of a Workshop on Electrocatalysis on Non-metallic Surfaces, held at the National Bureau of Standards, Gaithersburg, Maryland, on December 9-12, 1975. The Workshop was sponsored by the Institute of Materials Research, NBS, the Division of Materials Research of the National Science Foundation, and the Division of Conservation Research and Technology of the Energy Research and Development Administration. The purpose of the Workshop was to review the most recent experimental and theoretical investigations on electrocatalysis on nonmetals and related topics, and to bring together electrochemists, surfaces scientists, and solid state physicists and chemists involved in research related to this topic. A total of 31 invited and contributed papers are here presented, togetherwith a summary report of the final panel discussion. These proceedings are arranged to reflect, with some small exceptions, the program of the Workshop. The main groupings of papers are: I. Theory of Electrocatalysis and Related Topics; II. Characterization; III. Electrochemical Processes on Nonmetallic Surfaces; and IV. Electrochemistry at Solid Electrolyte Interfaces. In addition, a final panel discussion (V) considered major problems, advances and opportunities revealed by the Workshop.

SP456. **Measurements for the safe use of radiation.** Proceedings of an NBS 75th ANNIVERSARY Symposium held at the National Bureau of Standards, Gaithersburg, MD, Mar. 1-4, 1976, S. P. Fivozinsky, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 456*, 437 pages (Nov. 1976) SD Catalog No. C13.10:456, $5.15.

Key words: calibrations; environment; measurements; medical; radiation; standards.

These proceedings are the compilation of papers presented at the Symposium, "Measurements for the Safe Use of Radiation," held in Gaithersburg, Maryland, March 1-4, 1976. The symposium addressed the present status and future requirements for measurements of ionizing and nonionizing radiation. Emphasis was placed on the needs for standardization and measurement assurance activities in medical, environmental, and personnel protection applications.

SP457. **Building technology publications 1965-1975,** J. R. Debelius, S. G. Weber, and K. N. DeCorte, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457*, 107 pages (Dec. 1976) SD Catalog No. C13.10:457, $1.80.

Key words: abstracts; Center for Building Technology; key words; publications.

This report presents the National Bureau of Standard's (NBS) Center for Building Technology (CBT) publications of the past decade. Publications constitute a major end product of CBT's efforts. They appear in several publication series (Building Science Series, Technical Note, NBS Report, NBS Interagency Report, Handbook, Special Publication, the Journal of Research, and the Consumer Information Series).

SP459. **Performance evaluation of programmable robots and manipulators.** Report of a Workshop held at Annapolis, MD, Oct. 23-25, 1975, T. B. Sheridan, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 459*, 213 pages (Oct. 1976) SD Catalog No. C13.10:459, $3.40.

Key words: guidelines; industrial robots; manipulator; performance evaluation; programmable robots; specifications.

The Workshop brought together representatives of industry, academic institutions and government agencies, including the potential designers, suppliers and users of a new generation of manipulators and robots which include varying degrees of control by both people and computers. The Conference was motivated by the lack of common bases for comparing one such device with another in terms of performance, or one task with another in terms of how well a given device will perform it.

The Workshop concluded that there is a need for (1) common definitions of many terms which now are the source of pervasive confusion, (2) common test codes, (3) checklists, guidelines, and specifications to help users and suppliers better communicate with one another, and (4) common tests for demonstration and exhibition of new research and development in this field. Conference participants emphasized that once these needs were met to allow communication in the field, actual performance testing should be left to the user and supplier in the free marketplace.

SP460. **Use of Monte Carlo calculations in electron probe microanalysis and scanning electron microscopy.** Proceedings of a workshop held at the National Bureau of Standards, Gaithersburg, MD, Oct. 1-3, 1975, K. F. J. Heinrich, D. E. Newbury, and H. Yakowitz, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 460*, 169 pages (Feb. 1977) SD Catalog No. C13.10:460, $2.35.

Key words: electron probe microanalysis; electron-solid interactions, magnetic domains; Monte Carlo electron trajectory calculations; particle analysis; scanning electron microscopy; thin film analysis.

This book is the formal report of the Workshop on the Use of Monte Carlo Calculations in Electron Probe Microanalysis and Scanning Electron Microscopy held at the National Bureau of Standards, October 1-3, 1975. The papers cover a wide range of topics within the field: the history and development of Monte Carlo methods for use in x-ray microanalysis; the study of the distribution of electron and x-ray signals by Monte Carlo techniques; the effect of the choice of scattering models on the calculations; techniques for considering the distribution of energies of the beam electrons propagating in the specimen; evaluation of ionization cross-section models; and applications of Monte Carlo techniques to the study of particles, thin films, and magnetic domain images. The contributions include reviews of general interest as well as papers treating specific topics. The volume should be of wide interest to workers in the fields of scanning electron microscopy, electron probe microanalysis, electron physics, and other fields involving the interaction of electrons with solids.

SP462. **Laser induced damage in optical materials: 1976.** Proceedings of a Symposium Sponsored by: National Bureau of Standards, American Society for Testing and Materials, Office of Naval Research, Energy Research and Development Administration, Defense Advanced Research Project Agency, July 13-15, 1976, NBS Boulder, CO, A. J. Glass and A. H. Guenther, Eds., *Nat.*

Bur. Stand. (U.S.), Spec. Publ. 462, 410 pages (Dec. 1976) SD Catalog No. C13.10:462, $4.60.

Key words: avalanche ionization; infrared windows; laser damage; metal mirrors; optical fabrication; optical materials; thin films.

The Eighth Annual Symposium on Optical Materials for High Power Lasers, the Boulder Damage Symposium, was hosted by the National Bureau of Standards in Boulder, Colorado, from July 13th to 15th. The Symposium was held under the auspices of ASTM Committee F-1, Subcommittee on Laser Standards, with the joint sponsorship of NBS, the Defense Advanced Research Project Agency, the Energy Research and Development Administration, and the Office of Naval Research.

About 160 scientists attended the Symposium, including representatives of the United Kingdom, France, Canada, and Brazil. The Symposium was divided into five half-day sessions, concerning Bulk Material Properties and Thermal Behavior, Mirrors and Surfaces, Thin Film Properties, Thin Film Damage, and Scaling Laws and Fundamental Mechanisms.

As in previous years, the emphasis of the papers presented at the Symposium was directed towards new frontiers and new developments. Particular emphasis was given to new materials for use at 10.6 μm in mirror substrates, windows, and coatings. New techniques in film deposition, and advances in diamond turning of optics were described. The scaling of damage thresholds with pulse duration, focal area, and wavelength are discussed.

Alexander J. Glass of Lawrence Livermore Laboratory and Arthur H. Guenther of the Air Force Weapons Laboratory were Co-chairpersons of the Symposium. The Ninth Annual Symposium is scheduled for October 4-6, 1977, at the National Bureau of Standards, Boulder, Colorado.

NSRDS-NBS57. **Yields of free ions formed in liquids by radiation,** A. O. Allen, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 57*, 25 pages (Apr. 1976) SD Catalog No. C13.48:57, $0.55.

Key words: electrons; free ions; ion yields; liquid; nonpolar systems; radiation chemistry; radiation physics.

Free ions are those produced by ionizing radiation which escape initial recombination. Yields of free-ion pairs are tabulated for liquid alkanes, alkenes, alkynes, dienes and aromatic hydrocarbons, and other nonpolar and polar compounds, including alcohols, ethers, esters, halides, amines, nitriles, etc. Total ion yields for a few liquids are compared with gas phase ion yields. Theoretical treatments of these data are discussed.

BSS69. **NBSLD, the computer program for heating and cooling loads in buildings,** T. Kusuda, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 69*, 398 pages (July 1976) SD Catalog No. C13.29/2:69, $4.60.

Key words: ASHRAE task group on energy requirements; conduction transfer functions; heating and cooling load; National Bureau of Standards heating and cooling load computer program.

A comprehensive computer program called NBSLD, the National Bureau of Standards Load Determination program, has been developed at NBS to reflect the time change of the many building parameters which are pertinent to accurate estimation of energy usage for heating and cooling. Current status of heating and cooling load techniques is reviewed. Of general interest are unique features of NBSLD which are not available in existing computer programs. A summary of various subroutines of NBSLD is given along with the detailed procedures for them. These subroutines constitute the recommended subroutine algorithms of the ASHRAE Task Group on Energy Requirements. Complete Fortran listing of NBSLD and data preparation forms are given for those who wish to use the program. The NBSLD computation is on the basis of the detailed solution of simultaneous heat balance equations at all the interior surfaces of a room or space. Transient heat conduction through exterior walls and the interior structures is handled by using conduction transfer functions. The use of heat balance equations, although time-consuming in calculation, can avoid the vagueness and uncertainties inherent in the more popularly used weighting factor approach. In addition, it is more accurate for a specific building design.

BSS88. **Energy conservation in buildings—A human factors/systems viewpoint,** A. I. Rubin, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 88*, 19 pages (Nov. 1976) SD Catalog No. C13.29/2:88, $0.65.

Key words: energy conservation; human factors; people in buildings.

The current emphasis on energy conservation in buildings must be balanced by a careful consideration of how proposed approaches affect building occupants. A head-long rush toward building designs which conserve energy at the expense of the quality of buildings as judged by occupants, would be a very shortsighted approach. There must be a continual awareness and sensitivity of the consequences on people when selecting among alternative "technical" options designed as a result of energy conservation needs. We need an increasing understanding of such factors as thermal comfort and illumination needs in buildings, as decisions likely to influence these requirements are made by designers.

Another area of concern which should not be overlooked is the interactions of people with their environments. "Hardware" approaches to energy conservation problems are often defeated by building occupants. Tight seals around doors and windows are useless if doors and windows are kept open. Building occupants have no choice but to turn all of the lights on or off if these are the only control options available to them. Building managers, operators and occupants have an important, though not well understood role to play in any energy conservation program. This problem deserves serious attention.

BSS89. **The incidence of abnormal loading in residential buildings,** E. V. Leyendecker and E. F. P. Burnett, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 89*, 10 pages (Sept. 1976) SD Catalog No. C13.29/2:89, $0.75.

Key words: bombs; building codes; design criteria; explosions; gas; hazardous materials; loads; progressive collapse; sonic boom; vehicular collision.

The findings of an analysis of available U.S. statistics concerning the incidence of abnormal loading events in residential buildings are presented. The study evaluates natural gas explosions, bomb explosions, motor vehicle collision, sonic boom aircraft collision, and explosion of hazardous materials.

It is concluded that the gas related explosion, bomb explosion, and vehicular collision are of significance in building design for progressive collapse. Of these, the natural gas explosion is the most significant in terms of incidence. The gas explosion causing severe damage occurs with an annual frequency of 1.6 per million dwelling units and approaches a probability of 1×10^{-3} per apartment building per year.

BSS90. **The structure of building specifications,** S. J. Fenves, K. Rankin, and H. K. Tejuja, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 90*, 83 pages (Sept. 1976) SD Catalog No. C13.29/2:90, $1.45.

Key words: building code provisions; building codes; building component classification; building specifications; building standards; performance concept.

This paper provides a scientific basis for the formulation and expression of performance standards and specifications and for explicit

attention to performance in procedural and prescriptive standards and specifications.

The provisions of the NBS-developed *Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings*, a performance specification, are classified in terms of the physical entities addressed, the attributes of the built environment, and the properties which group together particular physical entities which may be subject to similar dysfunctions. These provisions are also subjected to a linguistic analysis which examines in detail the wording used and formalizes certain key concepts which are realized in the wording.

The provisions of the *Uniform Plumbing Code*, a prescriptive code, are classified in terms of the physical entities addressed and the performance attributes which can be inferred (though they are not explicitly addressed).

Guidelines for the expression of provisions in performance codes and specifications are presented. These guidelines are based on the classification studies and the linguistic analysis mentioned above.

BSS91. **The development of an improved test for evaluating the racking resistance of wall panels,** C. W. C. Yancey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 91*, 75 pages (Nov. 1976) SD Catalog No. C13.29/2:91, $1.40.

Key words: lateral loads; loading rate; racking; test method; vertical loads; wall panels; walls.

An experimental investigation of the primary factors involved in the laboratory testing of prototype wall panels, under simulated wind-induced racking loads, is reported. The objective of the investigation was to recommend a static racking test method, generally applicable to a variety of wall construction types, that features realistic boundary and loading conditions. Initially, a literature survey was conducted for the purpose of evaluating the test methods which have been, or are being employed in determining the resistance of wall panels to static racking loads. In the experimental program, 17 exploratory tests were conducted on a sample comprised of two types of wall panel construction. The 8 ft by 8 ft steel-frame and wood-frame panels were subjected to a combination of vertical and horizontal loading and their resulting deformation behavior was systematically monitored. Modifications to the testing procedure and to the boundary condition at the top of the panels were introduced as the experiments progressed. Detailed descriptions of the laboratory procedures used are presented. As the tests were developmental in nature and not intended for performance evaluation of the types of construction, selected results are presented. A static racking test method, applicable to traditional and innovative wall construction was derived as a result of the laboratory study and the literature survey. The principal new features of the proposed standard method are: (a) the application of distributed vertical loading, (b) the capability of testing panels of various height-to-width ratios and (c) the provision of top and bottom boundary conditions which do not force unrealistic modes of failure.

BSS92. **The viscosities of roofing asphalts at application temperatures,** W. J. Rossiter, Jr., and R. G. Mathey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 92*, 44 pages (Nov. 1976) SD Catalog No. C13.29/2:92, $0.70.

Key words: application temperature; asphalt; built-up roofing; interply thickness; roofing membranes; viscosity.

The optimum range of viscosity over which hot asphalt should be applied in the fabrication of built-up roofing membranes was determined to be 50 to 150 centistokes (mm^2/s). This viscosity range was based on the relationship between interply thickness and application temperature of asphalt obtained from roofing membrane specimens fabricated in the field. Because laboratory measurements showed a wide range of viscosities for roofing asphalts of the same type over their application temperature ranges, it was recommended that asphalts be applied at temperatures based on viscosity and not empirically determined temperature limits. In practice, the viscosity-temperature relationship should be determined for each roofing asphalt for the application temperature range prior to use. Using this relationship and the optimum viscosity range, the temperature range for applying each asphalt can be determined.

FIPS PUB 40. **Guideline for optical character recognition forms,** T. C. Bagg, Standard Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 40*, 60 pages (1976).

Key words: business forms; computers; data entry systems; information processing systems; information processing standards; OCR; OCR forms; optical character recognition; standards.

This publication provides materials relating to the design, preparation, acquisition, inspection, and application of OCR forms in data entry systems. Since the materials are advisory and tutorial in nature this publication has been issued as a guideline rather than as a standard in the FIPS publication series. Full color illustrations are employed to show specific features of reflective ink applications, a phenomena unique to OCR forms requirements. Appropriate references are made to cognizant standards in the OCR area.

FIPS PUB 44. **COBOL coding form,** M. V. Vickers, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 44*, 3 pages (1976).

Key words: COBOL; COBOL coding form; Federal Information Processing Standard; Federal Standard COBOL; software; standards conformance.

This publication provides a standard COBOL Coding Form (SF-268) together with an explanation of its use and physical specifications. The standard form is based upon a review and analysis of numerous COBOL coding forms being used throughout the Federal Government. The development of the standard form was accomplished through the cooperative efforts of FIPS Task Group 9 (COBOL) under the auspices of the National Bureau of Standards and the Interagency Reports and Standards Forms Division of the National Archives. It is anticipated that significant economic benefits will be realized by Federal departments and agencies as a result of the availability of a single standard form for government-wide use. This standard conforms to the provisions of Federal Standard COBOL (FIPS 21-1).

FIPS PUB 45. **Guide for the development, implementation and maintenance of standards for the representation of computer processed data elements,** H. S. White, Ed., *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 45*, 51 pages (1976).

Key words: American National Standards; computers; data; data elements; data processing; information; information processing; International Standards; U.S. Government.

Provides technical and administrative guidelines for the development, use and maintenance of standards for representing data elements used in computer based systems. Basic concepts and terminology of data standardization are provided in addition to evaluation criteria for assessing various coding alternatives. The guide is used as a basic reference document in the development of Federal and voluntary national and international standards for data. The guide was developed by the X31.81 Standards Task Group of the American National Standards Institute and has been adopted for use by the International Organization for Standardization.

PS66-75. **Safety requirements for home playground equipment.** *(ANS Z 304.1-1975)*, J. M. Tascher, Technical Standards Coordinator, *Nat. Bur. Stand. (U.S.), Prod. Stand. 66-75*, 14 pages (July 1976) SD Catalog No. C13.20/2:66.75, $0.45.

Key words: home playground equipment, safety of; jungle gyms, safety of; playground equipment, safety of; safety of home playground equipment; slides, safety of; swing sets, safety of.

This Voluntary Product Standard provides safety requirements for various types of home playground equipment intended for use by children aged from 2 through 10 years. The requirements are concerned with the design and performance of the units and their components, the structural integrity of the units and their components during and after exposure to static loads, and the instructions and information to be enclosed with the equipment. Methods of identifying products which comply with this standard are given.

TN594-11. **Optical radiation measurements: Development of an NBS reference spectrophotometer for diffuse transmittance and reflectance,** W. H. Venable, Jr., J. J. Hsia, and V. R. Weidner, *Nat. Bur. Stand. (U.S.), Tech. Note 594-11,* 47 pages (Oct. 1976) SD Catalog No. C13.46:594-11, $1.15.

Key words: bidirectional reflectance factor; diffuse reflectance; diffuse transmittance; reflectance; spectrophotometry.

A new reference spectrophotometer, designed primarily for the analysis of diffuse transmittance and reflectance, has been developed in the Institute for Basic Standards at NBS. The spectrophotometer consists of a broad band monochromator with optional bandpasses of 2, 5, 10, and 20 nanometers. The exit aperture of the monochromator is provided with special mirror optics to collimate and switch the beam for optional use as a reference or sample beam. These collimated beams are directed into a dark room where a variety of sample mounts, light gathering devices, and detectors can be installed. Measurements for which provisions have been made or are planned include directional-hemispherical reflectance of solids, liquids, and powders, directional-hemispherical reflectance as a function of angle of incidence, diffuse transmittance, haze, and bidirectional reflectance factor. This technical note describes the design of the instrument in detail, and gives the results of the performance tests and detailed error analyses which have been carried out to date.

TN594-12. **Optical radiation measurements: The translucent blurring effect—Method of evaluation and estimation,** J. J. Hsia, *Nat. Bur. Stand. (U.S.), Tech. Note 594-12,* 31 pages (Oct. 1976) SD Catalog No. C13.46:594-12, $0.75.

Key words: blurring effect; edge loss; error analysis; flux loss; plastics; reflectance; scattering; spectrophotometry; translucency; transmittance; Vitrolite glass.

The translucent phenomenon which causes flux loss in the spectrophotometric measurement is described. Methods for mathematically evaluating the flux loss are examined, and experimental methods using laser and conventional light sources are described. A widely used Vitrolite glass standard is employed to demonstrate the error estimation and correction.

TN682. **Implementation of the notch technique as an rf peak pulse power standard,** P. A. Simpson and P. A. Hudson, *Nat. Bur. Stand. (U.S.), Tech. Note 682,* 30 pages (July 1976) SD Catalog No. C13.46:682, $0.80.

Key words: notch wattmeter; pulse-CW equalization; pulse modulated carrier systems; rf peak pulse power.

The theory and operation of a standard for measuring rf peak pulse power is described. The standard is based on the "notch" principle. It is constructed in coax for frequencies up to 4.4 GHz, and in WR-90 waveguide (8.2-12.4 GHz). The basic range is 1 to 10 mW but is extendable to cover 10 μW to 10 kW using directional couplers. Risetime of the system is 14 nanoseconds. A comprehensive error analysis is given. The uncertainty in coax is 3 percent and in waveguide is 4 to 6 percent depending upon peak power level.

TN683. **Models for the interpretation of frequency stability measurements,** J. A. Barnes, *Nat. Bur. Stand. (U.S.), Tech. Note 683,* 44 pages (Aug. 1976) SD Catalog No. C13.46:683, $1.00.

Key words: flicker noise; frequency; frequency stability; oscillators; phase noise; stationary models.

The results of measurements of frequency stability are normally interpreted in the terms of models. Typically, these models are expressed as a power-law for the power spectral density (e.g., $S_y(f) = h_{-1}f^{-1}$). The experiments which provide the basis for these models are always limited in their range and include neither zero nor infinite Fourier frequency. Some authors have neglected the limits to the actual physical devices and the underlying data and have encountered mathematical difficulties with the models at either zero or infinite frequency or both. These problems are associated with the model and not the actual oscillators being modeled. By carefully taking into account actual limits of the device and constraining discussions to be concerned only with quantities which can be observed in a practical sense, one can avoid the problems of nonconvergence and nonstationarity.

Even for stationarity and convergent models, however, there is growing evidence that the typical Gaussian models may be inadequate. There appear to be occasional (sporadic) steps in the frequency of oscillators of a magnitude which is difficult to explain with conventional models.

TN686. **Ultrasonic calorimeter for beam power measurements,** T. L. Zapf, M. E. Harvey, N. T. Larsen, and R. E. Stoltenberg, *Nat. Bur. Stand. (U.S.), Tech. Note 686,* 36 pages (Sept. 1976) SD Catalog No. C13.46:686, $0.85.

Key words: calorimeter; ultrasonic calorimeter; ultrasonic power measurements.

An ultrasonic calorimeter has been designed and constructed at the National Bureau of Standards for the measurement of beam power up to a few watts from ultrasonic transducers. The calorimeter, described as a twin, series flow, ultrasonic calorimetric comparator, operates in the frequency range from 1 to 15 MHz with uncertainties less than $\pm(7\% + 0.2$ mW). Twin vessels are provided so that thermal effects of an ultrasonic sound beam absorbed in one vessel can be compared rapidly with accurately measured dc electrical power in the other vessel. Absorbing liquid enters each vessel near the ultrasonic input port. The temperatures of the absorbing liquid at the input ports are equalized by a heat exchanger, and the mass-flow rates are the same in both vessels. Twin temperature sensors, located in the output flow from the vessels, are connected in an electrical bridge circuit. In automatic operation the bridge is connected to a feedback circuit. With ultrasonic power introduced into one vessel, the feedback circuit promptly applies power to an electrical heater in the other vessel to regain bridge balance. The ultrasonic power then equals the measured dc power corrected for known errors.

TN687. **Measurement of rf power-absorption in biological specimens (10 to 100 MHz),** F. M. Greene, *Nat. Bur. Stand. (U.S.), Tech. Note 687,* 29 pages (Nov. 1976) SD Catalog No. C13.46:687, $0.75.

Key words: electromagnetic field hazards; electromagnetic field synthesizer; electromagnetic radiation-exposure testing (nonionizing); near-fields; rf biological hazards.

A method is described for accurately determining the rf power being absorbed by a biological specimen during nonionizing radiation-exposure testing using the NBS RF Near-Field Synthesizer in the frequency range 10 to 100 MHz. This method is based solely on measuring the forward and reflected power on the transmission line feeding the synthesizer. Commercially available rf wattmeters can be used, and an automatic data-acquisition system employed, if desired, to "read" the meters and rapidly calculate, display, and record the rf power flow.

The method has the advantage that the exact measuring point on the feed line is not critical, as it is with methods employing direct impedance measurements, and that the required measurements can be made without interfering with the exposure tests.

TN688. **Yagi antenna design,** P. P. Viezbicke, *Nat. Bur. Stand. (U.S.), Tech. Note 688,* 27 pages (Dec. 1976) SD Catalog No. C13.46:688, $0.65.

Key words: antenna; director; driven element; gain; radiation pattern; reflector; Yagi.

This report presents data, using modeling techniques, for the optimum design of different length Yagi antennas. This information is presented in graphical form to facilitate the design of practical length antennas—from 0.2λ to 4.2λ long—for operation in the HF, VHF, and UHF frequency range. The effects of different antenna parameters on realizable gain were also investigated and the results are presented. Finally, supplemental data are presented on the stacking of two or more antennas to provide additional gain.

TN689. **A simulation of the fluctuations of international atomic time,** J. A. Barnes, *Nat. Bur. Stand. (U.S.), Tech. Note 689,* 23 pages (Nov. 1976) SD Catalog No. C13.46:689, $0.55.

Key words: frequency stability; international atomic time; models; simulation; time scale simulation.

In the Annual Report for 1975 the International Time Bureau (BIH) published estimates of noise levels which model the fluctuations in the International Atomic Time Scale (TAI). Based on these noise levels for each type of noise, an Auto Regressive, Integrated, Moving Average (ARIMA) model is constructed. A resulting ARIMA model, which can simulate time fluctuations in TAI, is given by the relation

$$(1 - \phi_1 B - \phi_2 B^2)\Delta^2 \chi_t = (1 - \theta_1 B - \theta_2 B^2 - \theta_3 B^3 - \theta_4 B^4)a_t$$

where χ_t represents the time fluctuations in nanoseconds (ns) of TAI measured at successive intervals of ten days; B is the index-lowering operator defined by $B^n \chi_t \equiv \chi_{t-n}$; Δ^2 is the second difference operator equivalent to $(1 - B)^2$; a_t are random, independent variables with a normal distribution, zero mean, and variance of $(147 \text{ ns})^2$ and the coefficients ϕ_i and θ_i are given by

$$\phi_1 = 1.79, \theta_1 = 2.93,$$

$$\phi_2 = -.795, \theta_2 = -3.12, \theta_3 = 1.419, \theta_4 = -0.233.$$

TN690. **Is hydrogen safe?,** J. Hord, *Nat. Bur. Stand. (U.S.), Tech. Note 690,* 38 pages (Oct. 1976) SD Catalog No. C13.46:690, $0.85.

Key words: explosion; fire; fuel; gasoline; hydrogen; methane; safety.

The safety aspects of hydrogen are systematically examined and compared with those of methane and gasoline. Physical and chemical property data for all three fuels are compiled and used to provide a basis for comparing the various safety features of the three fuels. Each fuel is examined to evaluate its fire hazard, fire damage, explosive hazard and explosive damage characteristics. The fire characteristics of hydrogen, methane and gasoline, while different, do not largely favor the preferred use of any one of the three fuels; however, the threat of fuel-air explosions in confined spaces is greatest for hydrogen. Gasoline is believed to be the easiest and perhaps the safest fuel to store because of its lower volatility and narrower flammable and detonable limits. It is concluded that all three fuels can be safely stored and used; however, the level of safety risk for each fuel will vary from one application to another. Generalized safety comparisons are made herein but detailed safety analyses will be required to establish the relative safety of different fuels for each specific fuel application and stipulated accident. The technical data supplied in this paper will provide much of the framework for such analyses. Hydrogen safety guidelines, regulatory codes applicable to the distribution of hydrogen, and safety criteria for liquid hydrogen storage are compiled and presented.

TN691. **Clock synchronization and comparison: Problems, techniques and hardware,** J. E. Gray, *Nat. Bur. Stand. (U.S.), Tech. Note 691,* 12 pages (Nov. 1976) SD Catalog No. C13.46:691, $0.35.

Key words: chronograph; frequency-stability measurement; instrumentation; laboratory technique; time measurement.

This report summarizes a lecture-discussion of practical problems in measurement electronics as experienced in a laboratory for precise timekeeping. It includes environment problems, instrumentation problems, procedural problems, and ends with a description of a convenient automatic measuring instrument, the chronograph.

TN899. **Development of proposed standards for testing solar collectors and thermal storage devices,** J. E. Hill, E. R. Streed, G. E. Kelly, J. C. Geist, and T. Kusuda, *Nat. Bur. Stand. (U.S.), Tech. Note 899,* 265 pages (Feb. 1976) SD Catalog No. C13.46:899, $3.10.

Key words: solar collector; solar energy; solar radiation; standard; standard test; thermal performance; thermal storage.

A study has been made at the National Bureau of Standards of the different techniques that are or could be used for testing solar collectors and thermal storage devices that are used in solar heating and cooling systems. This report reviews the various testing methods and outlines a recommended test procedure, including apparatus and instrumentation, for both components. The recommended procedures have been written in the format of a standard of the American Society of Heating, Refrigerating, and Air Conditioning Engineers and have been submitted to that organization for consideration.

TN914. **A new dynamic pressure source for the calibration of pressure transducers,** C. F. Vezzetti, J. S. Hilten, J. F. Mayo-Wells, and P. S. Lederer, *Nat. Bur. Stand. (U.S.), Tech. Note 914,* 35 pages (June 1976) SD Catalog No. C13.46:914, $0.85.

Key words: calibration; dynamic; dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; transducer.

A dynamic pressure source is described for producing sinusoidally varying pressures of up to 34 kPa zero-to-peak, over the frequency range of approximately 50 Hz to 2 kHz. The source is intended for the dynamic calibration of pressure transducers and consists of a liquid-filled cylindrical vessel, 11 cm in height, mounted upright on the armature of a vibration exciter which is driven by an amplified sinusoidally varying voltage. The transducer to be calibrated is mounted near the base of the thick-walled aluminum tube forming the vessel so that the pressure-sensitive element is in contact with the liquid in the tube. A section of the tube is filled with small steel balls to damp the motion of the 10-St dimethyl siloxane working fluid in order to extend the useful frequency range to higher frequencies than would be provided by an undamped system.

The dynamic response of six transducers provided by the sponsor was evaluated using the pressure sources; the results of these calibrations are given.

TN917. **A review of network access techniques with a case study: The network access machine,** R. Rosenthal, *Nat. Bur. Stand. (U.S.), Tech. Note 917,* 36 pages (July 1976) SD Catalog No. C13.46:917, $0.85.

Key words: access procedures; command language; computer networks; job control language; macros; minicomputers; protocols; teleprocessing.

The computer industry's ability to serve a diverse and expanding

user community is evidenced by the rapid growth of computer network services. Computer service providers design and market their own offerings as they deem best, given their own market and their own set of resources. This has led to a proliferation of similar resources requiring different user access procedures. With emphasis on currently operating and planned systems that assist users in accessing available network services, this report identifies the techniques used in network access devices. By examining these devices, the trend toward improving the interface between the user and the computer is brought more clearly into focus and up to date.

One specific solution—A Network Access Machine (NAM)—is described in detail. The NAM is a minicomputer system that acts as a network access point for a user at his terminal and assists the user through the automatic execution of access procedures. This minicomputer facility allows the user to specify (or to have specified) his own network command sequences for execution on a specified network and host connected to that network. Computer responses are analyzed to assure agreement with those anticipated for specific commands. Conditional parameterized expansions allow the use of the same commands on different host computer and different networks.

TN918. **Survey of building code provisions for historic structures,** M. Green and P. W. Cooke, *Nat. Bur. Stand. (U.S.), Tech. Note 918*, 47 pages (Sept. 1976) SD Catalog No. C13.46:918, $1.15.

Key words: building codes; cities; health and safety; historic preservation; states.

In order to resolve conflicts between health and safety objectives and historic preservation objectives, a number of states and cities have adopted special building code provisions. A survey was conducted to determine the extent of adoption of such special provisions. The survey included the states, territories and member cities of the Association of Major City Building Officials (AMCBO). The survey responses revealed that sixteen of the forty-seven responding states have special provisions or regulations as do fifteen of the twenty-four responding cities. The majority of states and cities have established a special preservation appeals board. Legislation and special provisions are reviewed in the report. Recommendations for additional research are included.

TN919. **Operating system structures to support security and reliable software,** T. A. Linden, *Nat. Bur. Stand. (U.S.), Tech. Note 919*, 51 pages (Aug. 1976) SD Catalog No. C13.46:919, $1.25.

Key words: capability; capability-based addressing; computer security; extended-type objects; operating system structures; protection; reliable software; reliability; security; small protection domains; types.

Security has become an important and challenging goal in the design of computer systems. This survey focuses on two system structuring concepts that support security; namely, small protection domains and extended-type objects. These two concepts are especially promising because they also support reliable software by encouraging and enforcing highly modular software structures—in both systems software and in applications programs. Small protection domains allow each subunit or module of a program to be executed in a restricted environment that can prevent unanticipated or undesirable actions by that module. Extended-type objects provide a vehicle for data abstraction by allowing objects of new types to be manipulated in terms of operations that are natural for these objects. This provides a way to extend system protection features so that protection can be enforced in terms of applications-oriented operations on objects. This survey also explains one approach toward implementing these concepts thoroughly and efficiently—an approach based on the concept of capabilities incorporated into the addressing structure of the computer. Capability-based addressing is seen as a practical way to support future requirements for security and reliable software without sacrificing requirements for performance, flexibility, and sharing.

TN921. **Survey manual for estimating the incidence of lead paint in housing,** W. G. Hall and L. T. Slovic, *Nat. Bur. Stand. (U.S.), Tech. Note 921*, 111 pages (Sept. 1976) SD Catalog No. C13.46:921, $2.20.

Key words: lead paint; lead paint detection; lead paint programs; lead poisoning; portable x-ray fluorescence; random sampling; x-ray fluorescence.

This manual is intended as a guide for municipal managers in performing a survey to determine the prevalence of lead based paint in their community's dwelling units. There are four parts to the Manual, each is intended for a different audience.

Part I discusses the preliminary considerations for a survey. It is intended for the department head or executive who will initiate plans for the survey. It presents a managerial overview of the processes, the cost determinants, criteria for the establishment of objectives and the resources required.

Part II is intended for the survey manager and the inspector supervisors. It contains more detailed information on the planning, staffing, training, and execution of the data collection phase of the survey.

Part III is for the use of the person responsible for the control and management of the data collected and for the analysis of these data.

The Appendices contain quite detailed information about procedures we have used in previous surveys. These may be used as they are described or may be modified or adapted to meet specific objectives.

TN922. **Economic analysis of experimental lead paint abatement methods: Phase I,** R. E. Chapman, *Nat. Bur. Stand. (U.S.), Tech. Note 922*, 112 pages (Sept. 1976) SD Catalog No. C13.46:922, $1.75.

Key words: abatement; building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning.

Public and private concern about the potential for lead poisoning in children due to the ingestion of lead-based paint chips has resulted in a Federally sponsored program to develop technologies by which lead-based paint may be eliminated from the nation's housing. Through this program lead-based paint abatement techniques were tested in field deleading operations conducted in Washington, DC, and Atlanta, GA. The program also focused on the collection of data on the direct costs of labor, materials and special equipment associated with these abatement techniques.

This report provides a statistical analysis by abatement technique and building component (i.e., walls, doors, door frames, windows and frames, and miscellaneous trim) of this direct cost data. Abatement techniques are then ranked according to their relative costs. A cost model is developed for each category (ranking) which identifies the key factors which affect direct cost and provides a framework whereby direct costs may be estimated. Recommendations are made for further refinement of the model; a methodology through which the optimal combination of lead-based paint abatement techniques can be identified is also outlined.

TN923. **Applications of thermography for energy conservation in industry,** C. W. Hurley and K. G. Kreider, *Nat. Bur. Stand. (U.S.), Tech. Note 923*, 31 pages (Oct. 1976) SD Catalog No. C13.46:923, $0.75.

Key words: energy conservation; energy surveys; infrared; nondestructive evaluation; thermographic surveys; thermography.

Infrared thermography has been developed as a tool to measure the temperature of various types of surfaces. Notable applications include thermal detection of diseases such as cancer and circulatory problems in human beings, aerial land mapping of hot surfaces to de-

tect thermal pollution and geological formations, and remote scanning of buildings to detect heat losses. More recently, infrared scanning has been used to detect defects in high amperage electrical connections, transformers, and steel processing furnaces in industrial environments.

It was the intent of the NBS IR program to build on these technologies to assist energy conservation engineers to assess heat losses in industrial plants. IR teams from the NBS Center for Building Technology had previously used the equipment to survey heat losses in buildings where the IR camera was found to be particularly useful in detecting infiltration problems, missing insulation, and construction defects. Our intent in this project was to survey furnaces and heating systems in addition to electrical and mechanical systems to find areas suggesting energy conserving actions. This qualitative survey has been found to be an excellent method to detect heat losses in unit process equipment and auxiliary systems. This survey method described in this paper was carried out in fifteen industrial plants in order to develop a methodology and examine the feasibility of the approach.

In addition to the qualitative survey quantitative data was gathered by calibrating the temperature of the "hot spots" uncovered in the survey. This information was very useful in developing priorities and estimating the magnitude of the heat loss due to a given defect.

TN924. **Procedures for the calibration of ASTM E127-type ultrasonic reference blocks,** D. J. Chwirut, G. F. Sushinsky, and D. G. Eitzen, *Nat. Bur. Stand. (U.S.), Tech. Note 924*, 43 pages (Sept. 1976) SD Catalog No. C13.46:924, $1.05.

Key words: aluminum ultrasonic reference standards; ASTM-type reference standards; calibration; interim reference standard; longitudinal beam; measurement system; nondestructive evaluation; pulse-echo; ultrasonics.

A service for the calibration of ASTM E127-Type ultrasonic reference blocks has been established at the National Bureau of Standards. A single well-characterized reference block, carefully chosen to be as close as possible to "typical" or "nominal," has been designated as an interim standard against which other blocks can be compared. As refinements are made and the system becomes better understood, new standards may be developed leading to the development of an absolute national standard. The facilities and procedures used in this calibration service are described herein.

TN925. **Overviews and justifications for low gravity experiments on phase transition and critical phenomena in fluids,** M. R. Moldover, R. J. Hocken, R. W. Gammon, and J. V. Sengers, *Nat. Bur. Stand. (U.S.), Tech. Note 925*, 99 pages (Oct. 1976) SD Catalog No. C13.46:925, $1.70.

Key words: critical point; gravity effects; phase transitions.

Important scientific questions concerning pure fluids and fluid mixtures near critical points are identified and are related to the progress of several disciplines. Consideration is given to questions about thermodynamic properties, transport properties, and the complex nonlinear phenomena which occur when fluids undergo phase transitions in the critical region. We discuss, quantitatively, the limitations to answering these questions by experiments in the earth's gravitational field. The distinction is made between practical limits which may be extended by advances in technology and intrinsic ones which arise from the modification of fluid properties by the earth's gravitational field. The kinds of experiments near critical points which could best exploit the low gravity environment of an orbiting laboratory are identified. These include studies of the index of refraction, constant volume specific heat, and phase separation.

TN927. **Development of dynamic calibration methods for pogo pressure transducers,** J. S. Hilten, P. S. Lederer, C. F. Vezzetti, and J. F. Mayo-Wells, *Nat. Bur. Stand. (U.S.), Tech. Note 927*, 58 pages (Nov. 1976) SD Catalog No. C13.46:927, $1.15.

Key words: bias pressure; calibration; dynamic calibration; dynamic pressure; high pressure; liquid medium; pogo pressure; pressure source; pressure transducer; sinusoidal; space shuttle; transducer.

Two dynamic pressure sources are described for the calibration of pogo pressure transducers used to measure oscillatory pressures generated in the propulsion system of the space shuttle. Rotation of a mercury-filled tube in a vertical plane at frequencies below 5 Hz generates sinusoidal pressures up to 48 kPa, peak-to-peak; vibrating the same mercury-filled tube sinusoidally in the vertical plane extends the frequency response from 5 Hz to 100 Hz at pressures up to 140 kPa, peak-to-peak. The sinusoidal pressure fluctuations can be generated by both methods in the presence of high pressure (bias) up to 55 MPa.

Calibration procedures are given in detail for the use of both sources. The dynamic performance of selected transducers was evaluated using these procedures; the results of these calibrations are presented. Calibrations made with the two sources near 5 Hz agree to within 3 percent of each other.

TN928. **Computer programs for the evaluation of activity and osmotic coefficients,** B. R. Staples and R. L. Nuttall, *Nat. Bur. Stand. (U.S.), Tech. Note 928*, 56 pages (Dec. 1976) SD Catalog No. C13.46:928, $1.10.

Key words: activity coefficients; aqueous; computer programs; data evaluation; electrolytes; electromotive force; isopiestic method; osmotic coefficients; nonlinear least squares; thermodynamic properties; vapor pressure.

A number of specialized computer programs have been developed for the purposes of calculating thermodynamic properties directly from experimental data and for subsequent data manipulation, including nonlinear least-squares fitting of the data to empirical or semiempirical equations that describe the function over a range of compositions, temperatures or other parameters. The details of the programs used in the critical evaluation of mean activity and osmotic coefficients and sample runs for each program are discussed. Osmotic coefficients can be calculated from direct vapor pressure measurements or from isopiestic molalities. Activity coefficients can be calculated from electromotive force measurements of galvanic cells, both without liquid-junction and with transference. A nonlinear least-squares program fits data from all sources as a function of ϕ and $\ln \gamma$. Once the parameters of the fitting equation have been obtained, another program can be used to calculate a table of m, γ, ϕ, a_w, and ΔG^{ex} at rounded molalities.

TN929. **A survey of current literature on sampling, sample handling, and long term storage for environmental materials,** E. J. Maienthal and D. A. Becker, *Nat. Bur. Stand. (U.S.), Tech. Note 929*, 40 pages (Oct. 1976) SD Catalog No. C13.46:929, $0.85.

Key words: chemical analysis; environmental samples; long-term storage; microbiologicals; organics; pesticides; radionuclides; sample handling; sampling; trace elements.

This article is the result of an extensive literature survey to establish optimum sampling, sample handling and long term storage techniques for a wide variety of environmental samples to retain sample integrity. The components of interest in these samples are trace elements, organics, pesticides, radionuclides or microbiologicals. This survey was done both manually and by use of various bibliographical retrieval services. Also the advice and opinions of workers in various aspects of the fields was obtained.

TN930. **A measurement assurance program for electric energy,** N. M. Oldham, *Nat. Bur. Stand. (U.S.), Tech. Note 930*, 23 pages (Sept. 1976) SD Catalog No. C13.46:930, $0.55.

Key words: electric energy; electricity; electric power; measurement assurance; transport standard; watthour meter.

A Measurement Assurance Program for Electric Energy is described which enables a meter laboratory to evaluate the accuracy of its calibration process relative to the legal units of energy maintained by the National Bureau of Standards. A laboratory participating in this program periodically determines its process offset by testing an NBS transport standard as part of its regular workload (using the same procedures used to test its working standards). Subsequent monitoring and tests for local control can improve the reliability and assure the adequacy of the participant's calibration process.

TN931. **Environmental effects on microphones and type II sound level meters,** E. B. Magrab, Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 931,* 120 pages (Oct. 1976) SD Catalog No. C13.46:931, $1.85.

Key words: acoustic calibrators; A-weighting; barometric pressure; crest factor; ground cover; humidity; instrumentation; microphones; sound level meters; statistical control processes; temperature.

For four different manufacturer's Type II sound level meters numerous experimentally determined data concerning the effects of frequency, temperature, angle of incidence of the sound, and types of ground cover and reflecting surfaces on sound level meter readings are presented. Data are also given for the effects of ambient barometric pressure on several manufacturers' acoustic calibrators, the effect of frequency and crest factor on the sound level meters' detector circuit, the linearity of the sound level meters' range potentiometer and meter scale, and the precision of the A-weighted response in a randomly incident (diffuse) sound field. Additional data are given concerning the effects of temperature and humidity on the sensitivity of electret, condenser, and ceramic microphones. Finally, important statistical concepts and recommended data monitoring procedures are presented to insure that the precision of repeated sound level measurements is known.

TN932. **Concrete strength during construction,** H. S. Lew, T. W. Reichard, and J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 932,* 56 pages (Dec. 1976) SD Catalog No. C13.46:932, $1.35.

Key words: compressive strength; concrete; maturity; mechanical properties; nondestructive evaluation; pull-out strength; splitting tensile strength.

The early strength gain characteristics of a concrete at various temperatures was investigated in this study. In addition, the applicability of two widely known nondestructive evaluation methods were examined for the purpose of determining the compressive strength of concrete at early ages.

For destructive evaluation, standard cylinder compression tests, splitting tensile tests and pull-out tests were made on specimens cured at 73 °F (22.8 °C), 55 °F (12.8 °C) and 35 °F (1.7 °C). For nondestructive evaluation, both probe penetration and rebound hammer tests were performed on slabs. Tests were carried out at the age of 1, 2, 3, 5, 7, 14, 28 and 42 days after casting the concrete.

Statistical analyses were made to examine the possibility of using maturity of concrete as a parameter to correlate test results of concrete cured at different temperatures. Rate of gain of the splitting tensile strength, pull-out bond strength and elastic modulus were compared with that of compressive strength.

The results show that when related to maturity, the rate of increase in the splitting tensile strength is about the same as that of the compressive strength, whereas the rate of increase in the pull-out strength and the modulus are slightly greater than that of the compressive strength. The results of nondestructive evaluations revealed that the compressive strength could not be estimated correctly by the probe method using the manufacturer's conversion charts. Because of lower rebound readings, the rebound hammer could not be used to estimate the compressive strength at early ages.

NBSIR 74-452. **Design and evaluation criteria for energy conservation in new buildings,** Staff of the Center for Building Technology, NBS, 107 pages (Feb. 27, 1974). Order from NTIS as PB204586, $3.00.

Key words: air leakage; building design; energy conservation; fenestration; HVAC systems; illumination; insulation; lighting; performance standard; thermal performance; ventilation; water heating.

This document contains design and evaluation criteria for energy conservation in most new buildings. It was prepared in response to a request by the National Conference of States on Buildings Codes and Standards to the National Bureau of Standards. It is intended to be the forerunner of a consensus standard to be promulgated by a national standards organization.

The requirements and criteria are performance-oriented to the extent permitted by present building design technology. The performance concept is applied at the subelement or subsystem level to synthesize an energy-efficient total system. The detailed criteria are directed toward the design of building envelopes with good thermal resistance and low air leakage, and toward practices in the design of mechanical and electrical systems which conserve energy. Design flexibility is achieved by providing for the acceptance of alternative design solutions that can be shown to save equivalent amounts of energy without following every detailed requirement.

NBSIR 75-735. **An expandable total energy data editor,** R.H.F. Jackson, 151 pages (Aug. 1976). Order from NTIS as PB256295, $6.00.

Key words: computers; data editing; energy conservation.

This report documents the Total Energy Data Editor, a computer program developed to process the data to be collected by the ongoing Total Energy Project at the National Bureau of Standards. Consisting of a mix of FORTRAN and RAYTHEON machine language subroutines, the Editor is a powerful, interactive program written to be run on a Raytheon 704 minicomputer with two tape drives and a disk pack. Since this document is also meant as a user's manual, it includes a dictionary of commands, complete discussions and listings of individual subroutines, as well as an explanation of the workings of the program.

NBSIR 75-819. **Sensitive isotropic antenna with fiber-optic link to a conventional receiver,** E. B. Larsen, J. R. Andrews, and E. E. Baldwin, 108 pages (Sept. 1976). Order from NTIS as PB258554, $5.50.

Key words: electromagnetic compatibility; fiber optics; field strength measurement; isolated EMC antenna; sensitive isotropic probe.

A broadband, active, isotropic receiving antenna was developed at NBS for the frequency range 15 kHz to 150 MHz. It was designed for use with a conventional receiver to measure weak, near-zone electric fields of unknown polarization, such as leakage emanations from electronic equipment placed within a shielded enclosure. The antenna system consists of three mutually-orthogonal active dipoles, each 31 cm long by 3.5 cm diameter. The entire frequency range of each of the three field components is amplified and used to modulate a high-speed light emitting diode (LED) located inside the dipole. The modulated infrared (IR) signals are guided through glass fibers 10 meters long which connect the "isolated" dipoles to avalanche photodiodes at the far end of the fiber guides. These photodetectors recover the rf modulation from the IR carrier for input to the receiver.

The fiber-optic antenna system described in this paper has high sensitivity (down to 10 μV/m) and fast response time (rf modulations

up to 150 MHz). The readout indication at each receiver frequency is proportional to the Hermitian magnitude of E, which is the root-sum-square value of three orthogonal E field components at the measurement point. The linear dynamic range of the antenna system depends on the receiver bandwidth and signal frequency. It is 70 to 75 dB at frequencies between 0.02 and 2 MHz (for 0.5 kHz receiver bandwidth), 60 to 70 dB between 2 and 25 MHz (for 5 kHz receiver bandwidth) and 40 to 55 dB between 25 and 200 MHz (for 50 kHz bandwidth).

NBSIR 75-825. **The National Measurement System for cryogenics,** T. M. Flynn, 76 pages (Oct. 1975). Order from NTIS as PB258913, $4.50.

Key words: cryogenics; data; flowmeter; instrumentation; measurements; National Measurement System.

The Cryogenics Division of NBS has evolved as the nation's central laboratory for cryogenics, much as NBS itself has evolved as the nation's central laboratory with both broad and specific responsibilities. Cryogenic measurement and data outputs provide the common foundation for all the institutions and agencies throughout the nation employing cryogenics to solve their problems.

This Study of the National Measurement System showed that the Cryogenics Division of NBS provides almost every category of measurement and data service that NBS itself provides: not just an instrumentation system (including, for example, pressure, temperature, density, liquid level, flow rate, etc.), but also properties of fluids (both thermodynamic and transport properties); properties of solids (thermal, mechanical and electrical); an interface with the users through systems integration and advisory and consulting services; and a dissemination network through the Cryogenic Data Center.

This study documents the impact, status and trends of the cryogenic measurement system and specifically illustrates these characteristics wherever possible with a specific case study, a recently completed measurements and data program for the flow-metering of liquid nitrogen.

NBSIR 75-926. **The National Measurement System for length and related dimensional measurements, Part I,** J. W. Lazar and R. L. Bach, 115 pages (Aug. 1976). Order from NTIS as PB257467, $5.50.

Key words: dimensional; gage; instrument; laser; length; machine; measurements; standard.

The determination of length and related dimensional measurements constitute the largest group of measurements made in science, manufacturing and technology. We have shown that length and related dimensional measurements have impact upon many areas of the economy. We have also shown that the National Measurement System is viable and is adaptable in conforming to the changing requirements of industry. The greater accuracy requirements of some industries brought new measurement techniques into use, e.g., the fringe counting laser interferometer systems now used in many tool rooms and metrology laboratories. We have found no deficiencies in the system but only in individuals or the measurement technique that they use as shown in the comparison measurement on audit packages that were made by the various standards laboratories.

NBSIR 75-927. **The national measurement system for surface finish,** R. D. Young, 51 pages (July 1976). Order from NTIS as PB255809, $4.50.

Key words: economic factors; measurement; surface; surface finish; surface roughness; technology assessment.

NBS has conducted a study of the National Measurement System for Surface Finish. The proposed system model is discussed including the role of standards committees, instrument manufacturers and measurement users. The economic dimensions of the measurements impact areas and the technological base from which new measurement technology springs is described.

NBSIR 75-929. **A study of the National Force Measurement System,** D. E. Marlowe, 40 pages (June 1975). Order from NTIS as PB261498, $4.00.

Key words: dynamic force; economic; force; metrication; national measurement system; standards.

A study of the National Force Measurement System has been conducted. The overall structure of the system has been defined, and the size of several of its component elements has been measured. The interactions of many of these components within the system have been assessed. The position which NBS has and the role it plays in the system are better understood as a result of this study.

The best assessment of the condition of the National Force Measurement System is that areas such as static force measurement are fully adequate with the levels of accuracy now provided while other areas such as dynamic force measurements and information transfer, are very inadequate to serve even our present needs.

NBSIR 75-930. **The national measurement system for fluid flow,** W. C. Haight, P. S. Klebanoff, F. W. Ruegg, and G. Kulin, 66 pages (Aug. 1976). Order from NTIS as PB258250, $4.50.

Key words: aerodynamics; air flow; flow measurement; fluid flow; fluid metering; hydraulics.

Fluid flow is a diverse field concerned with the motion of a wide variety of fluids encountered both in daily life and in scientific applications. It encompasses movement of weather systems by atmospheric winds, travel and dispersion of air pollutants, flow around aircraft and spacecraft bodies, oil and gas pipeline flow, irrigation and waste water flow, and many others. The types of fluid motions encountered in descriptions of these phenomena include closed-conduit, open channel, supersonic, subsonic, steady, unsteady, laminar, and turbulent flow. Measurements of the properties of these flows are instrumental in the functioning of the nation's industries and the advancement of scientific technology, and impact the lives of every consumer.

This report presents the concept of the National Measurement System for Fluid Flow as it exists today and the activities and mechanisms employed within it to generate and implement measurement data. The system structure is presented, and data and information gathered on the interrelationships between the identifiable parts are reported. To further the study, more than 200 contacts were made with trade associations, government agencies, private companies, universities and laboratories.

This study was conducted over the time span June 1973 to December 1975.

NBSIR 75-931. **The National Measurement System for pressure,** P. L. M. Heydemann, 42 pages (Sept. 1976). Order from NTIS as PB261030, $4.00.

Key words: calibration; calibration chain; pressure; pressure measurement.

The state of the national measurement system for pressure in the range where NBS presently provides calibrations and related services is in a satisfactory state. Needs for expansion of the range have been identified and most of these needs will be satisfied in the near future.

Rapid changes in the needs of the system are generated by the increased use of transducers to transfer measurements and plans are being implemented at NBS to provide all necessary services.

NBSIR 75-932. **The National Measurement System for temperature,** J. F. Schooley, 61 pages (Aug. 1976). Order from NTIS as PB257425, $4.50.

Key words: data; International Practical Temperature Scale; measurements; National Measurement System; standards; thermometry.

The National Temperature Measurement System reaches quite literally into all phases of American life. Comfort control in home, school, office and factory, health care, manufacturing, food preparation and storage, and all forms of powered transportation are just a few of the many facets of America's human activities that depend for their trouble-free operation on the existence of reliable thermometry.

The Heat Division of the National Bureau of Standards collaborates with the national laboratories of other nations in establishing an International Practical Temperature Scale which represents thermodynamic accuracy insofar as current scientific practice permits. The NBS is the only U.S. agency bearing this responsibility; in addition, only the NBS is responsible for disseminating the International Scale to U.S. scientific and technical activities.

The Study of the National Temperature Measurement System shows that the NBS continues to contribute energetically to the quality of the International Scale. It further indicates that NBS maintains a consistent and deliberate effort not only to provide access to the Scale at the several levels required by U.S. science and technology, but also to participate in solving special problems in thermometry. These are problems for which the nature of NBS as an objective, expert resource in thermometry uniquely qualifies it to furnish effective, practical solutions.

In briefly describing the many aspects of the National Temperature Measurement System, this Study attempts to portray its great diversity of products, services, and people. The System is largely organized, as might be expected, for the purpose of economic gain; the NBS enters the picture only in those areas where highly accurate or intricate thermometry is essential.

NBSIR 75-942. **The national measurement system for optics,** D. A. Swyt, 63 pages (Aug. 1976). Order from NTIS as PB256644, $4.50.

Key words: imaging optics; lens testing; microcopy resolution charts; National Measurement System; photographic density; technology assessment.

NBS has conducted a study of the National Measurement System for Optics. The proposed system model is discussed including the role of standards committees, instrument manufacturers and measurement users. The economic dimensions of the measurements impact areas and the technological base from which new measurement technology springs are described.

NBSIR 75-943. **Transactions matrix description of the National System of Physical Measurements,** R. C. Sangster, 91 pages (Aug. 1976). Order from NTIS as PB258914, $5.00.

Key words: acoustic quantities; electrical quantities; electromagnetic quantities; end-use measurements; ionizing radiation; measurement activities; measurement institutions; mechanical quantities; National Measurement System; optical quantities; thermal quantities; time and frequency.

The interactions among the various elements of the National Measurement System are described in a series of transactions matrices. The National Measurement System consists of all of the activities and mechanisms used by this country to produce measurement data. The transactions matrices describe both the flow of measurement knowledge, goods, and services from suppliers to users in this System, and the activities within a given supplier-user sector. Semiquantitative estimates are made for the magnitude of the transactions, the rate of change of that magnitude, the relative importance or criticality of the transactions, and their adequacy. Basic supplier-user matrices have been developed for the system as a whole and for some 24 different measurement sectors (time and frequency; length and related dimensional measurements; vibration and shock; surface finish; mass, volume and density; force; fluid flow; pressure; temperature; humidity and moisture; thermodynamic properties of fluids; cryogenics; electricity; electromagnetics; medical ultrasonics; acoustics; radiometry and photometry; spectrophotometry; far ultraviolet radiometry; optics; lasers; physical properties of atoms and molecules; surface properties; and ionizing radiation). Some 25 supplier-user sectors have been defined, ranging from technical infrastructural institutions through governmental agencies to a series of commercial-industrial sectors defined by Standard Industrial Classification codes, to the "general public." Combination of like rows or columns from the basic supplier-user matrices for the different measurement sectors has allowed the generation of total input and output matrices for each supplier-user sector.

NBSIR 75-944. **National measurement system for the physical properties of atoms and molecules,** J. W. Cooper, A. V. Phelps, and S. J. Smith, 39 pages (Sept. 1976). Order from NTIS as PB258372, $4.00.

Key words: atom; energy generation; industrial technology; molecule; primary standards; properties.

National activity in measurement, compilation, evaluation, and dissemination of atomic and molecular data, estimated at 20-25 million dollars annually, impacts directly upon applied research and development projects costing over one-third billion dollars annually. NBS atomic and molecular programs, costing about 3 million dollars annually, provide the basis for the accepted standards for length, time and frequency; provide advanced measurement techniques; set rigorous performance standards for generation of atomic and molecular data, and provide for the construction of a sound data base for the user community. The largest users are programs aimed at energy generation and converstion. Basic sciences of aerodynamics, astrophysics, atmospheric physics and plasma physics are important users. Benefits for a broad range of industrial research activities are potentially large. It is recommended that NBS undertake to ensure the reliability and adequacy of the data base needed for important national programs, expand its contacts with private industry, develop increased awareness of the methodology for applying atomic and molecular data to technological development, and encourage effective utilization of this sector of the measurement system for the benefit of the economy.

NBSIR 75-947. **Collected executive summaries, Studies of the National Measurement System 1972-75,** R. C. Sangster, 56 pages (Aug. 1976). Order from NTIS as PB258323, $4.50.

Key words: acoustics; atomic properties; economics; electrical quantities; ionizing radiation; mechanical quantities; national measurement system; optical quantities; surface properties; thermal quantities; time and frequency.

This report contains the Executive Summaries of the reports of the 1972-75 study by the NBS Institute for Basic Standards of the U.S. National Measurement System, which consists of all of the activities and mechanisms which provide physical measurement data required by our society. A series of microstudies focused on specific technical measurement sectors. A macroeconomic study looked at costs of instrumentation and labor for measurement-related activity in our economy. University economists were retained to assist the microstudy authors and to prepare an overall economics report. A central coordinator set a basic pattern for the microstudies, prepared an overall summary report, and generated several documents relating to thesystem as a whole. Abbreviated titles of the executive summaries are: Final summary report. Direct measurements transactions matrices. Economic analysis. Structure and functions of measurement system. Time and frequency. Length and related dimensional measurements; vibration and shock. Surface finish. Mass, volume and density. Force. Fluid flow. Pressure. Temperature. Humidity and moisture. Thermodynamic properties of fluids. Cryogenics. Electrici-

ty. Electromagnetics. Medical ultrasonics. Acoustics. Radiometry and photometry. Spectrophotometry. Far ultraviolet radiometry. Optics. Physical properties of atoms and molecules. Surface properties. Ionizing radiation.

NBSIR 75-953. **A procedure for determining bicycle braking performance,** D. E. Marlowe, 26 pages (July 1976). Order from NTIS as PB256219, $4.00.

Key words: bicycles; braking; consumer safety; handbrakes; testing.

A procedure which could be used to determine bicycle braking performance for compliance with the Federal Bicycle Safety Regulation, Requirements for Bicycles, has been developed. The procedure includes tests for brake system integrity and stopping distance performance. Sample data collection sheets and calculations are given.

NBSIR 75-961. **The police patrol car: Economic efficiency in acquisition, operation, and disposition,** R. T. Ruegg, 225 pages (June 1976). Order from NTIS as PB257466, $7.75.

Key words: fleet management; life cycle costing; patrol cars; police fleets; vehicle leasing; vehicle management.

This study uses the techniques of life cycle costing to analyze some of the decision problems of police fleet management. It addresses the following questions: (1) What are the cost effects of purchasing different sizes of patrol cars and different optional equipment? (2) What are the advantages and disadvantages of direct ownership of vehicles as compared with leasing vehicles? (3) How do the costs of contracting out maintenance compare with costs of an in-house shop? (4) What are the effects of alternative utilization practices on fleet costs? (5) How often should vehicles be replaced? (6) What method of vehicle disposition is most efficient? The techniques used to compare costs of alternative systems are described in a chapter on life cycle costing methodology. Cost estimates and empirical data are presented in the many tables, exhibits, and charts which support the study. Existing fleet practices are described. Findings of the study are expressed as general guidelines for fleet management. The focus of the study is on police patrol cars, but the methods are applicable to other kinds of vehicles.

NBSIR 75-972. **Skid resistance measurement tests at the FHWA eastern field test center,** R. W. Kearns and J. F. Ward, 98 pages (July 1976). Order from NTIS as PB259630, $5.00.

Key words: accident reduction, skidding; correlation, skid resistance; highway safety; pavement, skid resistance; pavement wetting system, tire-pavement interface forces; wet pavement.

The measurement of the skid resistance of highways, under wet weather conditions, is part of the Federal Highway Administration (FHWA) skid accident reduction program. To standardize and to improve the precision of the measurements, the program includes national and regional reference systems to which the highway measuring systems may be systematically related. This report describes evaluation tests conducted at the FHWA Eastern Field Test Center (EFTC) which included the use of the Eastern Area Reference System (EARS) and the Interim Reference System (IRS) maintained by the National Bureau of Standards. The performance characteristics of the EARS, its subsystems and a correlation equation between the EARS and the IRS are presented. A method of quantifying sources of dispersion is applied to the measurements made by the IRS on the EFTC reference surfaces. Recommendations for modifications to the EARS, the test procedures, and EFTC facilities are made.

NBSIR 76-836. **Low temperature fracture behavior of a Ti-6Al-4V alloy and its electron beam welds,** R. L. Tobler, 49 pages (Apr. 1976). Order from NTIS as PB254459, $4.00.

Key words: electron beam welding; fatigue; fracture toughness; low temperature tests; mechanical properties; titanium alloy.

The effects of electron beam (EB) welding on the fracture behavior of a recrystallization annealed, extra-low-interstitial Ti-6Al-4V alloy have been investigated at temperatures in the ambient-to-cryogenic range. Plane strain fracture toughness (K_{Ic}) and subcritical crack growth parameters were measured using compact specimens 10 to 25.4 mm-thick. These parameters can be used to predict the safe operating lifetimes of cryogenic pressure vessels and other welded Ti-6Al-4V structures.

Although EB welding transforms the base metal microstructure extensively, its effects on the material's fatigue crack propagation resistance at intermediate stress intensity factors are negligible. The growth rates, da/dN, of fatigue cracks sited in the fusion and heat-affected zones of weldments were temperature insensitive and nearly equivalent to rates for the base metal. However, welding introduces a zone of low fracture toughness at the heat-affected-zone/fusion-zone boundary. The K_{Ic} value for this boundary zone at liquid nitrogen temperature (76 K) was 45 $MN/m^{3/2}$, 16 percent lower than the base metal. The base metal fracture toughness increases between 4 and 295 K, with an abrupt transition to higher K_{Ic} values occurring at temperatures between 76 and 125 K. Static load cracking, temperature effects, and specimen orientation effects on the fracture behavior of this titanium alloy are central topics of discussion.

NBSIR 76-840. **FM-CW electromagnetic technique of measuring coal layer thickness,** D. A. Ellerbruch and D. R. Belsher, 38 pages (May 1976). Order from NTIS as PB258324, $4.00.

Key words: automation; coal; coal mine safety; dielectric constant; energy; microwave measurement; nondestructive testing; thickness of coal layer.

An FM-CW microwave system was investigated for measuring coal layer thickness. Measurements were made in three different mines near Pittsburgh, Pa., near Fairview, W. Va., and near Coffeen, Ill. Microwave frequencies in the range 1-2 GHz were used to measure samples up to 55 cm thick. All samples were backed with a naturally occurring shale. Measurements were also made on coal and shale samples compounded in the laboratory at the Bureau of Mines Pittsburgh Mining and Safety Research Center near Bruceton, Pa.

The results indicate that layer thickness can be determined in most cases, although large anomalies may, in some cases, produce misleading results. Many anomalies that were detected with the FM-CW system were verified visually by drilling into the coal layer.

The dielectric constant of coal apparently varies significantly within a coal seam.

The form of the output signals from the FM-CW system seem to simplify the data interpretation and analysis process as compared to the manually swept microwave system used previously. It appears that this technique has the potential of measuring changes in the dielectric constant of a coal seam and providing an output that can be used for real-time corrections in layer thickness measurement.

NBSIR 76-841. **An analytical and experimental determination of the cutoff frequencies of higher-order TE modes in a TEM cell,** J. C. Tippet, D. C. Chang, and M. L. Crawford, 27 pages (June 1976). Order from NTIS as PB256319, $4.00.

Key words: shielded strip line; TEM cell.

In addition to the TEM mode, higher order TE and TM modes can propagate in a TEM cell. Since only the TEM mode is desired, the higher-order modes restrict the useful frequency range of the TEM cell. In this paper, the cutoff frequency of the first higher-order mode is obtained both analytically and experimentally for several TEM cells of differing geometry. The difference between the experimental and theoretical results is shown to be only a few percent. In addition the field distribution of the first higher-order mode is found explicitly.

NBSIR 76-842. **Error equations used in the NBS precision G/T measurement system,** W. C. Daywitt, 21 pages (Sept. 1976). Order from NTIS as PB258331, $3.50.

Key words: error analysis; G/T; precision measurements; radio star; satellite communications.

Equations presently being used in the precision NBS G/T measurement system are presented in this report. Included are the assumptions upon which these equations are based and sample calculations showing how the measurement errors vary with antenna elevation angle.

NBSIR 76-846. **An NBS phase noise measurement system built for frequency domain measurements associated with the Global Positioning System,** S. R. Stein, 30 pages (Aug. 1976). Order from NTIS as PB258327, $4.00.

Key words: Global Positioning System; phase-locked loop; phase noise measurement system; spectral density of phase.

A self-contained system is described which was constructed to perform phase noise measurements for the first phase of the Global Positioning System (GPS). It is capable of evaluating a pair of similar oscillators or a single oscillator and a frequency synthesizer using the phase-lock technique. Three features have been included to simplify the operation of the instrument: internal circuitry automatically detects an out-of-lock condition; an optimized second order phase-lock loop reduces phase error by a factor of 10^5 over a first order loop; selection of operating mode is made by a single front panel switch.

NBSIR 76-984. **Improved ultrasonic standard reference blocks,** G. F. Sushinsky, D. G. Eitzen, D. J. Chwirut, C. J. Bechtoldt, and A. W. Ruff, 129 pages (Nov. 1976). Order from NTIS as PB262020, $6.00.

Key words: aluminum ultrasonic standards; ASTM-type reference standards; calibration; fabrication variables; immersion testing; interim reference standard; longitudinal waves; metallurgical variables; nondestructive evaluation; pulse echo; steel ultrasonic standards; titanium ultrasonic standards; ultrasonics.

A program to improve the quality, reproducibility and reliability of nondestructive testing through the development of an improved ASTM-type ultrasonic reference standards system is described. Reference blocks of aluminum, steel, and titanium alloys are considered. Equipment representing the state-of-the-art in laboratory and field ultrasonic equipment was obtained and evaluated. RF and spectral data on twenty-two sets of ultrasonic reference blocks were taken as part of a task to quantify the variability in response from nominally identical blocks. Techniques for residual stress, preferred orientation, and microstructural measurements were refined and applied to reference blocks rejected by manufacturers during fabrication in order to evaluate the effect of metallurgical condition on block response. The effects of certain dimensional variables on block response were studied and new fabrication techniques considered. A study of the effects of measurement system variables on block response was carried out. A calibration service for ASTM E127-type reference blocks has been established and the development of a loaner service for calibration blocks is underway.

NBSIR 76-1002. **Industrial process data for fluids: A survey of current research at the National Bureau of Standards,** H. J. White, Jr., Editor, 55 pages (Apr. 1976). Order from NTIS as PB257469, $4.50.

Key words: industrial process data; project summaries; quantitative numerical data.

This report summarizes current activities sponsored by three groups within the National Bureau of Standards that are involved with the production of industrial process data for fluids. The three groups involved are the Cryogenics Division, the Equation of State Section of the Heat Division, and the Office of Standard Reference Data; other organizations in NBS and outside are also involved in various ways. The report takes the form of a listing of projects with some detailed information about each. Some of the projects are designed to provide industrial process data directly. Others systematically cover types of data that are of continual utility in industrial process calculations with the result that the data produced will be used for industrial purposes as well as for other purposes. A few of the projects attack problem areas that must be resolved before proper industrial process data in the area can be obtained. All of the projects focus on quantitative numerical data obtained for direct measurement, critical evaluation of data from the literature or theoretical estimation or calculation. This report has been prepared to show interested readers the interrelationships within a set of projects that might otherwise pass unnoticed because different organizational units within NBS are involved. Continued interaction between the program managers involved leads to interactions between the projects so that the listing is not a listing of independent unreacting projects but rather a listing of interacting projects following broad programmatic lines.

NBSIR 76-1011. **Exploratory study of glowing electrical connections,** W. J. Meese and R. W. Beausoliel, 30 pages (Oct. 1976). Order from NTIS as PB259641, $4.00.

Key words: arcing/sparking; branch circuit; contact resistance; electrical connections; fire hazard; glowing electrical connections.

This report describes and characterizes with quantifiable electrical and thermal measures the extent to which loose electrical connections in residential-type branch circuits have overheated in the laboratory. With loose electrical connections, which conceivably could be inadvertently duplicated in field installations, but with otherwise normal installation and operating conditions, visible glows have been observed under laboratory test conditions in nominal 120-volt, 15 and 20 ampere branch circuits with both copper and aluminum wire. Characteristics of the glow condition are differentiated from arcing/sparking as sometimes observed in making or breaking electric circuits.

Glowing electrical connections may dissipate as much as 35 watts of power with a current of 15 amps in the circuit and as much as 5 watts with a current of 0.8 amp in the circuit. Temperatures over 750 °F were measured on the "break-off tab" of receptacles. Metal outlet boxes housing glowing connections in an insulated wall test set-up representative of a common type of residential construction attained temperatures in excess of 450 °F. In laboratory tests under repetitive, intermittent and periodic cycles, a connection on a steel wire-binding screw of a receptacle open to the air had sustained glow conditions maintained for over 100 hours. Glowing connections will not perceptibly affect the electrical performance function of lights, appliances or other electrical loads, and will not "blow" fuses, trip circuit breakers or operate ground fault circuit interrupters.

NBSIR 76-1012. **Fire performance testing of bulkhead insulation systems for high strength to weight ship structures,** B. T. Lee, 64 pages (Aug. 1976). Order from NTIS as PB257197, $4.50.

Key words: aluminum bulkhead; combustion gases; fire endurance; insulation; intumescent paint; potential heat; reinforced plastic; small furnace test; smoke.

Sixteen insulated aluminum bulkhead specimens were subjected to a material screening process as well as evaluated for their comparative fire performance with a 2-foot horizontal slab furnace. Two insulated and two unprotected glass-reinforced plastic specimens were also tested to obtain fire performance data on these structural materials. In addition, painted aluminum and steel panel specimens were included to determine the fire protective merits of two types of

intumescent paints. Potential heat release, smoke, and combustion gas generation were also determined for the insulation and coating materials. Specimens insulated with organic base foams released high levels of combustion gases and could contribute considerable heat to an on-going fire. Specimens insulated with either refractory fibrous material or with mineral wool gave the best overall performance. The same thickness of insulation needed to protect an aluminum panel for over an hour can provide up to 20 minutes of protection for a glass-reinforced plastic panel of the same thickness. The intumescent paints did little to protect the specimens during the fire exposure. Parameters of insulation thickness, heat capacity, density, and thermal conductivity as well as fire duration on specimen temperature were analytically investigated.

NBSIR 76-1013. **Flame spread of carpet systems involved in room fires,** K. M. Tu and S. Davis, 42 pages (June 1976). Order from NTIS as PB256130, $4.00.

Key words: carpet systems; carpets; fire safety; flame spread; floor coverings; flooring radiant panel test; ignition sources; pill test; room fires.

This study was designed to test the hypothesis that given a situation where a chair or other item of furniture becomes the first item to burn in a room (providing the ceiling and walls are noncombustible), there is little reason to expect involvement of the carpet in the fire beyond the immediate vicinity of the burning object. Four small-sized carpet fire tests and eight full-scale burn room fire experiments were conducted. Experimental data for temperature distribution and incident heat flux to the floor covering were measured in the rooms. General analysis of the experimental results obtained shows this to be the case. It also is evident that the critical radiant flux of the floor covering system is predictive of the extent of burning. From this study, carpet systems used in rooms will not normally spread fire provided they meet the requirements of DOC FF 1-70 (the pill test).

NBSIR 76-1018. **Evaluation of the fire performance of carpet underlayments,** S. Alderson and L. Breden, 69 pages (Sept. 1976). Order from NTIS as PB257779, $4.50.

Key words: carpets; fire; flammability; floor coverings; pad; underlayments.

A series of carpet underlayments was evaluated for fire performance in a corridor configuration using the same carpet in all tests. Carpets with underlayments flashed over during corridor tests. In a series of small-scale tests, such as the smoke density chamber and the radiant panel, the flammability properties of the carpet tended to mask the flammability properties of the underlayment. The exception to this masking effect was the results from the flooring radiant panel test where the thermal conductivity of the underlayment influenced the burning characteristics of the carpet. High concentrations of toxic combustion products were observed at the time of flashover in the corridor, with both cellulosic and synthetic underlayments. Smoke optical density values for the various carpet plus underlayment combinations were approximately the same in the flaming mode, except for the integral pad system which has a higher value.

NBSIR 76-1020. **Guide criteria for laboratory evaluation of backflow prevention devices for protection of potable water supplies,** G. C. Sherlin, R. W. Beausoliel, and L. S. Galowin, 44 pages (Mar. 1976). Order from NTIS as PB258256, $4.00.

Key words: backflow; backflow prevention devices; back pressure; backsiphonage; guide criteria; potable water protection; plumbing guide criteria.

This report describes laboratory evaluation procedures which could be required for the approval of backflow prevention devices used to protect potable water supplies against contamination. Performance-based requirements, criteria, and general evaluation considerations that administrative authorities should require for approval of devices are presented. Recommendations for the development of tracer tests are submitted for further consideration. This document results from an investigation undertaken for the Environmental Protection Agency (EPA).

NBSIR 76-1021. **Fire spread along a mobile home corridor,** E. K. Budnick, 58 pages (July 1976). Order from NTIS as PB257101, $4.50.

Key words: corridor fire test; interior finish material; intumescent coating; life safety; mobile home; smoke detector; surface flame spread.

A series of tests was conducted in the corridor area of a typically constructed mobile home. These tests were designed to: (1) evaluate the performance of a variety of combinations of wall and ceiling materials as a result of exposure to a typical ignition in a full-scale mobile home corridor, and (2) determine the relationship between full-scale tests and laboratory flammability tests, particularly the ASTM E-84 tunnel test, a measure of surface flame spread.

The tests were restricted to one set of conditions in which the living room at the end of the corridor was exposed to a fire resulting from ignition of a standardized 6.4-kg (14-lb) wood crib. Nine tests were conducted with seven different combinations of wall and ceiling materials.

Performance of the various combinations of wall and ceiling materials was examined based on the time to reach untenable conditions in the corridor. Measurements utilized in evaluating levels of tenability included gas temperatures, surface temperatures, irradiance, concentrations of oxygen and carbon monoxide, and smoke densities.

Under this set of test conditions, it was found that the extent of fire spread and the time to reach untenable conditions are significantly influenced by the surface flame spread characteristics of the wall and ceiling finish materials in the corridor.

For a mobile home corridor with conventional wall and ceiling linings (ASTM E-84:FSC = 200 max), untenable conditions were reached in the corridor in less than four minutes. With class A (FSC = 25 max) wall and ceiling materials in the corridor, untenable conditions were not reached.

NBSIR 76-1022. **Evaluation of thrown objects tests for proposed safety standard for power lawn mowers,** D. C. Robinson and R. B. Clough, 25 pages (June 1976). Order from NTIS as PB259628, $3.50.

Key words: dispersion tests; lawn mowers; penetration tests; power lawn mowers; safety standard; thrown objects tests.

An evaluation was made of thrown objects dispersion and penetration tests which have been developed for a proposed safety standard for power lawn mowers. To evaluate the proposed laboratory dispersion tests, supplementary outdoor dispersion tests were conducted on walk-behind lawn mowers in which actual grass cutting conditions were simulated. A description of these outdoor tests, a comparison of the outdoor and laboratory dispersion tests for a sample of walk-behind lawn mowers, and an evaluation of the proposed dispersion and penetration tests is given. The evaluation includes a theoretical discussion of the penetration of thrown objects which is related to experimental results in terms of the shape, size and velocity of the thrown projectiles.

NBSIR 76-1023. **Direct comparisons of the NBS absorbed dose calorimeters irradiated with 20 and 50 MeV electrons,** S. R. Domen, P. J. Lamperti, and T. Mikado, 23 pages (July 1976). Order from NTIS as PB256191, $3.50.

Key words: absorbed dose; calorimeter; calorimetric comparisons; electron beams.

Two NBS absorbed dose calorimeters were compared in 20 and 50 MeV electron beams that were scattered with lead foils of various thickness. The internal structures of the calorimeters are identical. The nonportable model is enclosed in a 40 cm × 40 cm × 30 cm thick graphite medium while a 30 cm diameter × 15 cm thick graphite medium was used to enclose the portable model. Measured results indicate that the three internal bodies of the calorimeters and their measuring circuits were constructed with sufficient care to produce essentially identical calorimetric responses to about 0.1 percent.

NBSIR 76-1024. **Statistical analysis of blood lead levels of children surveyed in Pittsburgh, Pennsylvania: Analytical methodology and summary results,** W. D. Urban, 75 pages (Apr. 1976). Order from NTIS as PB255876, $4.50.

Key words: blood; blood lead; children; housing; lead paint; lead poisoning; surveys.

A survey was conducted in Pittsburgh, Pennsylvania to estimate the incidence of lead paint in housing and to develop a survey methodology that could be used in other metropolitan communities for that purpose. A secondary objective of the survey was to determine whether a causal relationship could be found between blood lead levels of children aged 7 years or less, living in the surveyed dwellings and the presence of lead paint in those dwellings. This report deals with the latter objective. For the children tested in Pittsburgh, the incidence of elevated blood lead levels defined as 40 micrograms of lead per 100 milliliters of blood or greater, was found to be less than 1 percent, too low to permit the establishment of a causal relationship. There was a significant correlation between the blood lead levels of the children living in the older homes and the fraction of contaminated surfaces within the dwellings. In addition, there was a significant correlation between the blood lead levels and the age of the dwellings in which the children resided. This correlation appeared to be independent of the lead paint levels in the dwellings. This report presents a summary of the survey procedures, the blood lead measurement process and associated problems and the more significant results of the analysis of the housing/blood lead data obtained in Pittsburgh.

NBSIR 76-1029. **Unitary heat pump specification for military family housing,** C. W. Phillips, B. A. Peavy, and W. J. Mulroy, 30 pages (Aug. 1976). Order from NTIS as PB261199, $4.00.

Key words: heating and cooling; military family housing; specification; unitary heat pump.

The purpose of this report is to establisn, for unitary heat pump equipment, the requirements for performance, testing, rating, design, safety, serviceability and reliability for system and components; and conformance conditions. This report is intended for guidance in military procurement and applies to hermetic electrically-driven vapor-compression unitary heat pumps of the remote (split) and packages (integral) types, the air-to-air and water-to-air classes, and sizes from 17,000 to 84,000 Btu/hr for both heating and cooling functions.

NBSIR 76-1041. **Security analysis and enhancements of computer operating systems,** The RISOS Project, Lawrence Livermore Laboratory, 70 pages (Apr. 1976). Order from NTIS as PB257087, $4.50.

Key words: BBN-TENEX; IBM OS/360; operating system security; security flaws; software security; taxonomy of integrity flaws; UNIVAC 1100 Series OS.

The protection of computer resources, data of value, and individual privacy has motivated a concern for security of EDP installations, especially of the operating systems. In this report, three commercial operating systems are analyzed and security enhancements suggested. Because of the similarity of operating systems and their security problems, specific security flaws are formally classified according to a taxonomy developed here. This classification leads to a clearer understanding of security flaws and aids in analyzing new systems. The discussions of security flaws and the security enhancements offer a starting reference for planning a security investigation of an EDP installation's operating system.

NBSIR 76-1046. **Improved building design through the psychology of perception: Perceptual selectivity applied to livability and safety with sample performance requirements,** N. Starnes, R. Wehrli, and R. Cormack, 103 pages (July 1976). Order from NTIS as PB256476, $5.50.

Key words: architectural psychology; architectural research; building research; building safety; perception; stair safety research.

For over a decade, architects have been calling for applications from social science which would contribute to building design better suited to the building's users. This report provides such applications relying upon the state-of-the-art knowledge of the psychology of perception, showing how human perception operates in the everyday use of buildings, and then drawing upon this rationale to present building requirements to guide the design and construction of safer stairs in future buildings. The building safety "requirements" have been written in the format and style of the *Guide Criteria for the Design and Evaluation of Innovative Housing Systems*, a housing performance specification written by NBS for HUD's large housing experiment, Operation Breakthrough. The report is directed toward both building designers (who could consider the use of the stair safety requirements for their own building projects) and architectural psychology researchers (who could take the proposed requirements as a set of hypotheses in further research and experimentation).

NBSIR 76-1049. **The electron factor in catalysis on metals electrocatalysis on nonmetallic surfaces,** L. H. Bennett and A. D. Franklin, 71 pages (May 1976). Order from NTIS as PB256600, $4.50.

Key words: catalysis; electrocatalysis; electrochemistry; electrodes; fuel cells; surface physics and chemistry.

Two related workshops were held at the National Bureau of Standards in Gaithersburg, MD, December 9-12, 1975, in topics of importance for energy conversion. These topics, concerned with some of the science underlying the development of fuel cells for electric utility use, are: (1) The Electron Factor in Catalysis on Metals; and (2) Electrocatalysis on Non-Metallic Surfaces.

This report includes discussions of the needs and expected benefits, lists of attendees, descriptions of the programs, and summaries of the major problems, advances, and opportunities revealed by the workshops.

NBSIR 76-1052. **Naval shipboard fire risk criteria—Berthing compartment fire study and fire performance guidelines,** B. T. Lee and W. J. Parker, 86 pages (Sept. 1976). Order from NTIS as PB258118, $5.00.

Key words: fire tests; flame spread; heat release rate; ignition; reduced scale models; room fires.

Judicious application of shipboard materials and choice of compartment furnishings can significantly reduce the threat of serious fire on board ship. Unfortunately the fire performance of materials is currently difficult to ascertain from laboratory fire tests on the materials. Full size and quarter-scale compartment fires in conjunction with an analytical treatment were performed to obtain an improved understanding of the relationships between the laboratory fire test assessment and the observed behavior of materials in actual fires. The compartment fire experiments indicated that the tempera-

ture of the hot air layer below the ceiling is a suitable quantitative measure of the level of fire buildup in a compartment. When this temperature exceeds 700 °C there is sufficient radiation from the hot air layer and the heated upper surfaces to cause ignition of all combustible materials in the compartment. For a 3 × 3 × 2.1 m (10 × 10 × 7 ft) space lined with asbestos millboard having a 0.68 × 1.9 m (27 × 75 in) open doorway a heat production rate of about 72 kW/m² (6.3 Btu/s/ft²) of deck area is enough to attain this condition. Fires in some bunk configurations alone could exceed this critical rate of heat generation. Ventilation and its points of application were found to be very important considerations. Observations of the fire scenarios in the compartment tests along with an empirical and analytical analysis of fire growth in compartment spaces have resulted in an improved application of the fire test ratings. Consequently more rational design rules for fire safe material usage have been developed taking into account the ignitability, flame spread, rate of heat release, potential heat and smoke generation potential of materials. The study also indicated the practicality of using quarter-scale fire tests for studying fire performance in full size compartments.

NBSIR 76-1058. **Performance of mobile homes—Summary report,** J. H. Pielert, W. E. Greene, Jr., L. F. Skoda, and W. G. Street, 143 pages (Apr. 1976). Order from NTIS as PB262097, $6.00.

Key words: computer techniques; construction; enforcement process; housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; standards.

This project was funded at the National Bureau of Standards by the Department of Housing and Urban Development with the objective of documenting mobile home performance problems and relating them to possible inadequacies in the ANSI A119.1 Standard for Mobile Homes and the mobile home enforcement process. Additionally, the durability of mobile home components was a study objective for potential use in mortgage insurance evaluation. Mobile home performance data were obtained for 4,105 mobile homes, categorized and related to the project objectives. This summary report is the last of a series of four project reports. It documents the project approach, results of the various tasks, and presents conclusions and recommendations. This was a problem-oriented study and did not attempt to document the many areas of satisfactory mobile home performance.

NBSIR 76-1059. **Intermediate minimum property standards for solar heating and domestic hot water systems,** Solar Energy Program Team, Center for Building Technology, 171 pages (Apr. 1976). Order from NTIS as PB257086, $6.75.

Key words: solar buildings; solar collectors; solar domestic hot water systems; solar heating; standards; thermal storage.

This report presents standards for the use of solar heating and domestic hot water systems in residential applications. The standards have been developed for application in numerous housing programs of the Department of Housing and Urban Development and are a companion document to be used in conjunction with the HUD "Minimum Property Standards for One and Two Family Dwellings," 4900 and "Minimum Property Standards for Multifamily Housing," 4910. To the greatest extent possible, these standards are based on current state-of-the-art practice and on nationally recognized standards including the MPS and the HUD "Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings."

NBSIR 76-1061. **An annotated bibliography on proton affinities,** K. Hartman, S. Lias, P. J. Ausloos, and H. M. Rosenstock, 52 pages (July 1976). Order from NTIS as PB256328, $4.50.

Key words: basicity; bibliography, appearance potential; heat of formation; ion-molecule equilibrium; proton affinity; proton transfer.

This bibliography consists of approximately 150 references about proton affinities which covers the period from 1932 through 1975. This includes experimental determinations of proton affinities in the gas phase (through observation of proton transfer reactions, ion-molecule equilibria, and appearance potential measurements) as well as determinations from crystal lattice energies and other miscellaneous techniques. Also included are reviews concerned with or related to proton affinity determinations.

NBSIR 76-1063. **Air leakage measurements in a mobile home,** C. M. Hunt, S. J. Treado, and B. A. Peavy, 27 pages (Aug. 1976). Order from NTIS as PB257102, $4.00.

Key words: air infiltration measurement; air leakage measurement; mobile home tightness; sulfur hexafluoride tracer measurement.

Air leakage measurements were made in a mobile home using sulfur hexafluoride (SF_6) as a tracer gas. The home was located in an environmental chamber where it was possible to measure and control the temperature outside the home. The effect on infiltration rate of a number of variables was determined. These included inside-outside temperature difference, simulated wind, installation of storm windows, opening of doors, and operation of the furnace fan. Experiments were also performed in which a fan was sealed to an opening in the house and inside-outside pressure difference measured as the fan blew air into or out of the structure at measured rates.

NBSIR 76-1067. **Mathematical approaches to evaluating aircraft vertical separation standards,** J. F. Gilsinn and D. R. Shier, 50 pages (May 1976). Order from NTIS as PB257195, $4.00.

Key words: aircraft; air transportation; air traffic control models; altimetry; altitude; aviation; collision risk; error analysis; mathematical models; safety; separation; vertical separation.

Above Flight Level 290, current regulations require aircraft to be separated vertically by at least 2000 feet. Because of increased traffic desiring to fly at these altitudes, the possibility of reducing the required separation (while maintaining acceptable safety levels) is under study. This report details many of the components of vertical position error and classifies them into three major categories: static pressure system error, altimeter instrument error, and pilot response error. Two models for use in evaluating separation standards, the root sum of squares (RSS) approach and the Reich collision risk model, are described together with their respective advantages and disadvantages. A final section includes recommendations for a carefully designed data collection effort and discusses potentially important considerations for such a design.

NBSIR 76-1069. **Environmental effects on the strength of a glass fiber-reinforced-plastic rod material,** N. Halsey and L. Mordfin, 38 pages (July 1976). Order from NTIS as PB256296, $4.00.

Key words: antenna-support materials; environmental degradation; guys, nonmetallic; marine atmospheres; plastics, fiber-reinforced; pultrusions; stress-rupture testing; sunlight; ultraviolet radiation; weatherability.

Environmental stress-rupture test methods were developed for studying the weatherability of materials under stressed exposure to marine atmospheres and intense sunshine. These laboratory test methods were applied to a coated, pultruded, glass fiber-reinforced-plastic rod product, with the marine atmosphere simulated by a salt-water fog and intense sunshine simulated by ultraviolet radiation. Static tests of the material, conducted both before and after the environmental exposures, were used to characterize both the as-received mechanical properties of the product and the reductions in tensile strength attributable to the weathering actions. The experimental results essentially confirmed the rod manufacturer'scontention that the effects of sunlight and weathering on the product range

from none to slight. For applications as antenna guys, the results suggest that the strength limitations imposed on rods by conventional end fittings, and by the fact that rods are frequently bowed rather than straight, tend to overshadow any strength reductions attributable to environments of the types considered here.

A failure analysis of a tower guy, fabricated from material of the type tested in this investigation, is given in an appendix.

NBSIR 76-1070. **Evaluation of backflow prevention devices: A state-of-the-art report,** G. C. Sherlin and R. W. Beausoliel, 142 pages (June 1976). Order from NTIS as PB260913, $6.00.

Key words: backflow; backflow preventers; back pressure; back-siphonage; cross connections; health hazard; potable water; vacuum breaker; water supply.

A significant potential for potable water supply contamination exists within all water supply systems due to backflow and cross connections. Surveillance of the water supplies to protect from such hazards requires continuing vigilance by the administrators of cross-connection control programs, and continuing upgrading of technical criteria and methods of evaluation.

The Environmental Protection Agency assists local (usually municipal) authorities, through the State water supply agency, in establishing and operating cross-connection control programs. Essential to these programs are (1) information on the suitability of commercially available devices for use in potentially high-hazard locations, and (2) practical and effective standardized test methods for evaluation of devices. The National Bureau of Standards investigation reported herein addresses the two needs identified.

This study includes a systematic review of the literature, together with consultations and visits with water purveyors, plumbing officials, laboratory officials and researchers in this field. Emphasis has been placed on those devices, test methods, and laboratory practices considered most essential to an effective assessment of the state-of-the-art. Also, test development needs were identified in a few areas of greatest concern.

NBSIR 76-1074. **Operation manual for 30,000 lbf constant-load testing machine,** D. E. Marlowe and W. H. Appleton, 31 pages (Oct. 1976). Order from NTIS as PB261497, $4.00.

Key words: creep; instrumentation; stress rupture; testing machine.

A 30,000 lbf (133 kN) constant-load testing machine has been designed, and ten of these machines have been delivered to the NASA Langley Research Center. Each machine is equipped with a self-contained, closed loop load controller which is maintained at a constant temperature, independent of the external ambient conditions.

NBSIR 76-1081. **Progress report on the corrosion behavior of selected stainless steels in soil environments,** W. F. Gerhold, E. Escalante, and B. T. Sanderson, 77 pages (Aug. 1976). Order from NTIS as PB256329, $5.00.

Key words: coatings; corrosion behavior; field tests; galvanic couples; soil environment; stainless steels; stress-corrosion behavior.

In order to obtain more definitive information regarding the corrosion and stress corrosion of stainless steels in soil environments, NBS in cooperation with the Committee of Stainless Steel Producers, AISI, initiated in 1970 a soil burial program in representative soil environments. Test materials included coated and uncoated sheet specimens in the annealed and sensitized condition, uncoated welded tubing specimens and galvanically coupled and uncoupled stressed and unstressed specimens. To date approximately 10,000 specimens have been buried at six soil test sites. This report contains the results obtained for specimens buried for up to approximately four years.

NBSIR 76-1082. **A survey of State legislation relating to solar energy,** R. M. Eisenhard, 166 pages (Apr. 1976). Order from NTIS as PB258235, $6.75.

Key words: architecture; buildings; design; energy; legislation; solar; State.

This report reviews enacted State legislation dealing with solar energy. Acts involving tax incentives, reduced property assessments, research and development, solar easements and solar energy promotion are identified and abstracted. The responsible State agency and official are listed. Acts and supporting forms and other information are included as appendices.

NBSIR 76-1083. **Report to AID on a Philippines survey on standardization and measurement services,** H. S. Peiser and R. S. Marvin, Eds., 124 pages (June 1976). Order from NTIS as PB255803, $5.50.

Key words: building technology; information handling; measurement services; Philippines; standardization; testing facilities.

A survey of standardization and measurement services in the Philippines was carried out in May 1975 as part of a National Bureau of Standards Program sponsored by the Office of Science and Technology of the Agency for International Development. The Survey Team included five NBS staff members, one other U.S. participant, three third-country participants, and a number of Philippine specialists. The Survey was made under the direction of Mr. Vidalito F. Ranoa, Director of the Philippine Bureau of Standards.

The team was divided into five groups which concentrated on: Technical Standards Committee Management, Metrication, Building Technology, Technical Information Handling, and Testing Facilities. Each group made extensive visits to the governmental, academic, and private organizations and facilities relevant to their topic. In each area the report summarizes the existing situation, identifies current problems, and offers suggestions and recommendations for their resolution.

NBSIR 76-1084. **Nondestructive examination of glass-reinforced-plastic rod end fittings,** G. F. Sushinsky and L. Mordfin, 28 pages (Aug. 1976). Order from NTIS as PB257180, $4.00.

Key words: end fitting; glass-reinforced-plastic rod end fitting; nondestructive examination; neutron radiography; ultrasonics; x-radiography.

An exploratory study was performed on the feasibility of using nondestructive examination techniques to detect voids in two types of potted compression end fittings. Four methods of nondestructive examination were tried: conventional pulse-echo ultrasonics, ultrasonic holography, x-radiography, and neutron radiography. The ultrasonic and x-ray methods that were tried proved unsatisfactory as a nondestructive examination tool for the two types of end fittings, and the neutron radiographic procedures successfully displayed the internal structure of only one of the specimen types. The procedures and results from the different methods of examination are summarized. Additional comments are given regarding the application of the methods to aluminum-jacketed specimens, and regarding improved methods for the inspection of steel-jacketed specimens.

NBSIR 76-1087. **On a scattered-light measuring device for use in testing types of smoke detectors,** M. Pistor, 35 pages (July 1976). Order from NTIS as PB257202, $4.00.

Key words: fire detection; light extinction; light scatter; light-scatter measurements; photoelectric smoke detectors; smoke detectors.

Generally, the response threshold value of fire detectors is tested with measuring instruments which operate on the same physical principle as the detectors to be tested. For example, this means that the response threshold value of an ionization measuring chamber and the

response threshold value of an optical-type smoke detector operating on a light extinction principle is checked using an extinction measuring instrument. However, optical-type smoke detectors operating on a light-scatter principle (photoelectric in U.S. parlance) have also been checked using an extinction measuring instrument.

Since the light-scatter type of smoke detector is by far the most commonly used of the optical type of smoke detector it seems appropriate to use a light-scatter measuring instrument to check the response threshold value of these detectors. In addition, the need for such a measuring instrument is emphasized by the fact that both the parameters of the smoke aerosol and the design features of the measuring instrument are affected in different ways by light scatter and light extinction.

The author describes the technical features and design details of a newly-developed, light-scatter measuring instrument along with some experiments to determine its response to artificially-generated aerosols.

NBSIR 76-1091. **Materials for fuel cells,** L. H. Bennett, M. I. Cohen, A. L. Dragoo, A. D. Franklin, and A. J. McAlister, 39 pages (May 1976). Order from NTIS as PB257768, $4.00.

Key words: cerium dioxide; degradation; electrocatalysis; fuel cells; refractory hard metal; solid electrolytes.

This report describes the research plans and initial progress on the NBS program of research on Materials for Fuel Cells. Transition metal carbides, borides, and nitrides ("refractory hard metals," or RHM) are being examined as potential hydrogen oxidation electrocatalysts for use in acid fuel cells. Preliminary screening of 19 carbides and borides has revealed apparent stability in hot (up to 160 °C) phosphoric acid for TaB, MoB, NbC, TaC, Mo_2C, and WC. More sophisticated tests for acid stability for these materials are under way. Equipment for examination of the electrochemical behavior of these materials as hydrogen oxidation electrocatalysts in phosphoric acid electrolytes at temperatures up to 150 °C is being completed, and tests will be started on these materials shortly. Additional materials in the general RHM class, including a number of nitrides, have been ordered and will be screened for acid stability. More extensive exploration will be made of the properties of TaC and WC as a function of stoichiometry and presence of other metals and of oxygen. Plans exist for a parallel study of oxides as oxygen reduction electrocatalysts for acid fuel cells not under support of this project. The current effort is devoted to improving and expanding the facility for electrochemical measurements. The long-term stability of CeO_2-based solid electrolytes, which are promising new candidate materials for the high-temperature fuel cells, is under study. Materials for fabricating specimens of CeO_2 doped with Gd_2O_3 or Y_2O_3 have been obtained or ordered, and arrangements made to hot press them. Experiments have been designed to examine degradation of the electrical properties at temperatures from 500 to 1100 °C, with and without a constant current throughout the degradation anneals. Compositions will be chosen around those giving a maximum conductivity, and the oxygen partial pressure will be fixed at a convenient value. AC admittance measurements will be used to monitor the electrical properties. Furnaces and ancillary equipment are being assembled or constructed.

NBSIR 76-1093. **The application of test structures and test patterns to the development of radiation hardened integrated circuits: A review,** K. F. Galloway and M. G. Buehler, 15 pages (Aug. 1976). Order from NTIS as PB256318, $3.50.

Key words: hardened integrated circuits; integrated circuits; radiation effects; radiation hardening; test patterns; test structures.

Government sponsored research and development on semiconductor devices intended for application in radiation environments often relies on test structures arranged into test patterns for device design information and process characterization. Problems unique to a radiation environment are often analyzed using test structures such as MOS capacitors and break-out transistors. The work reviewed in this report clearly demonstrates the importance of test structures in isolating and identifying problem areas. However, the measurement methodology associated with test structures is seldom reported which makes it difficult to compare the results of different workers. Also, the work reported to date using test structures and test patterns for assessing radiation effects has involved the relatively slow-speed laboratory testing of statistically insignificant numbers of test structures. Test patterns could be used by buyers of radiation hardened devices for (1) vendor selection and qualification, (2) process validation for hardness screening and hardness assurance, and (3) identification of circuit parameters critical to hardness assurance. However, before this can effectively be done, it is necessary that standardized modular test structures be designed to measure parameters of known importance to device hardness, that statistically significant numbers of test structures be measured with high-speed integrated circuit testers, and that the data reduction and analysis routines be well established.

NBSIR 76-1095. **Properties and interactions of oral structures and restorative materials,** J. M. Cassell, 77 pages (Aug. 1976). Order from NTIS as PB255808, $5.00.

Key words: adhesion; adsorption; alloys; composites; dental; grafting; investments; polymer; resin; wear.

A diversity of techniques is being directed toward development of new and improved dental restorative and caries-preventive materials. These have included: surface characterization of dental materials and coupling agent-coated hydroxyapatite by water adsorption; further evaluation of a novel testing approach for investigating the adhesive capability of coupling agents; synthesis of selected monomers for potential application as components of a dental composite restorative system or a pit and fissure sealant application; and investigation of techniques such as grafting with 2-cyanoacrylates and urethanes containing free isocyanate groups for modifying natural tooth and bone surfaces so as to achieve a more compatible surface for adhesion. Failure of the data acquisition and control system of a prototype pin on disc *in vitro* wear test procedure for dental restorative materials to record data consistently and to maintain proper measurement point trigger position have dictated construction of a new wear test unit that incorporates the successful design of the prototype unit, but that will allow for testing of multiple specimens and should permit data to be accumulated with a confidence level of 95 percent, as compared to the 90 percent level previously attained. Procedures have been developed for the investigation of nonprecious alloys used in crown and bridge application.

NBSIR 76-1096. **Guidelines for the determination and development of generic safety standards,** R. G. Hendrickson, 58 pages (Aug. 1976). Order from NTIS as PB257076, $4.50.

Key words: management need; operations research—NS.

These guidelines were prepared to assist the CPSC in the development of generic safety standards. This development is based on conceptual models of product hazard interactions and analyses of accident sequences, product clustering, and hazard characteristics.

The motivation for these guidelines derives from a perceived need to expedite the standard development process and to enhance the efficiency of standards for consumer product safety.

NBSIR 76-1097. **Illustrative generic standard for the control of thermal burn hazards in household appliances,** R. G. Hendrickson, E. M. Robertson, and R. V. Kelly, 49 pages (Aug. 1976). Order from NTIS as PB257141, $4.00.

Key words: burn hazards, household appliances; fault-tree dia-

grams; generic safety standards; household appliances; operations research; thermal burn hazards.

This document reports on the development of an illustrative generic standard for controlling hot surfaces associated with certain categories of consumer products. The development includes evaluations of accident data, fault-tree diagrams, theoretical heat-flow phenomena, current standards, and application of the thermesthesiometer as a test instrument.

This work is a companion to the Guidelines for the Development of Generic Safety Standards, and as such, it applies the methods and techniques provided in the Guidelines. The principal tool of analysis is the fault-tree method. This method brings to safety problems a versatile and insightful way of depicting events, conditions, and causes associated with hazards and accidents.

The intent is to demonstrate the feasibility of the generic approach to controlling safety aspects of consumer products. Although the illustrative standard is based on a study of actual data, the conclusions are not to be construed as final or authoritative.

NBSIR 76-1098. **Daylighting of buildings. A compendium and study of its introduction and control,** J. K. Holton, 39 pages (Oct. 1976). Order from NTIS as PB259523, $4.00.

Key words: daylight gathering; daylighting of buildings; energy conservation; lenses; light conduits; light control; reflectors; skylights; windows.

We can no longer ignore daylight as a valuable natural resource for building illumination. Significant reductions in the energy consumption of buildings are possible by decreasing the dependence on artificial illumination and decreasing air conditioning loads by employing methods which bring in cool light. In order to design buildings utilizing daylight effectively there must be an understanding of the design principles of daylighting. This requires a knowledge of illumination to meet the needs of the building users, an understanding of characteristics of daylight at the location of the building, and imagination in developing ways to introduce and control daylight. This paper is directed toward the identification of innovative techniques for the introduction and control of daylight. It is arranged in three sections: a Compendium, a Study section, and a Reference section. The Compendium presents a number of state-of-the-art methods to assist the designer in successfully employing daylight more extensively. The Study section provides more detailed information on these methods so an increased understanding can be developed of those which appear to have suitability in a given situation. Finally, the References provide background for further investigation.

The Study organizes daylighting methods as they relate to three zones of a building, the perimeter, the intermediate and the deep zone. Each has different characteristics and is suited to daylighting by different methods.

NBSIR 76-1099. **Standardization and measurement services in Bolivia,** H. S. Peiser, R. S. Marvin, and J. Mejeur, Eds., 105 pages (Sept. 1976). Order from NTIS as PB258612, $5.50.

Key words: Bolivia; measurements; quality control; standardization; testing facilities.

A survey of standardization and measurement services available in Bolivia was carried out in June 1974 as part of a National Bureau of Standards program sponsored by the Office of Science and Technology of the Agency for International Development. The Survey Team included 4 NBS staff members, 3 third-country participants, and 11 leaders of technology and standardization in Bolivia. The Survey was made under the direction of Engineer Orlando Donoso Torrez, then the Director General of the Bolivian General Directorate of Standards and Technology.

After two days of joint activities, the Team was divided into three groups which visited various industrial, university, and government installations in the Cochabamba, Santa Cruz, and La Paz areas respectively. This report contains brief summaries of these visits and of the problems related to standards and measurements reported by the organizations visited. It also includes the results of a questionnaire distributed to most of the organizations visited in advance of the Survey.

A brief report of the conclusions and recommendations of the Survey Team is included in "Peiser, H. Steffen, and Marvin, Robert S., ed., Regional Seminar on a System of Standardization and Metrology for Latin America, NBSIR 76-988 (U.S.), 96 pages (1976)."

NBSIR 76-1100. **Appraisal of Federal Government Cobol standards and software management: Survey results,** D. R. Deutsch, 75 pages (June 1976). Order from NTIS as PB258371, $4.50.

Key words: ADP; COBOL; Federal ADP installations; Federal Standard COBOL; impact evaluation; sample; software management; survey.

This report summarizes the results of a survey of selected Federal Government Automatic Data Processing (ADP) installations. Undertaken primarily as an evaluation of National Bureau of Standards (NBS) activities in support of the standardization of the COBOL programming language, the study also dealt with software management tools and practices.

The survey sample was selected from a subset of all known Federal Government ADP units; specifically, only domestic installations with at least one general purpose hardware system capable of supporting a modern COBOL compiler were included. Responses were received from over 70 percent of the 190 installations included in the sample.

The major portion of this document is made up of tabular summarizations of all responses for each survey question. Gross statistics and frequency distributions are presented on a question-by-question basis. No interquestion relationships are analyzed. The appendices include a comprehensive discussion of the sampling methodology and survey mechanics and a reproduction of the survey instrument with cross references to response tabulations appearing in the report.

NBSIR 76-1102. **Computer programs for structural chemistry: STATUS. A FORTRAN program for statistical analysis of crystallographic quantities,** L. W. Schroeder and B. Dickens, 152 pages (July 1976). Order from NTIS as PB257729, $6.75.

Key words: crystallographic data; errors; probability plots; residuals; statistics; uncertainties.

This report describes a FORTRAN computer program for evaluation of (i) the results of crystallographic least-squares refinements by examination of the residuals, (ii) differences in sets of data collected by different methods from the same crystal, (iii) differences in data sets collected by the same method from different crystals of the same material, and (iv) the differences in parameters in different models representing the crystal structure of the same material.

Part of the evaluation is accomplished by plots of residuals against the expected normal distribution quantiles. Additional plots compare residuals with the independent variable, d*, and with the calculated variable $Fc^2/\sin 2\theta$. The Miller indices can be used to divide a data set into various classes and octants so that the possibility of anisotropic effects can be examined.

The program will treat up to 7200 data points in each of two experimental data sets or 1000 structural parameters, and is oriented specifically towards examining crystallographic data.

NBSIR 76-1107. **Considerations in developing test methods for protective headgear,** R. E. Berger, 55 pages (Aug. 1976). Order from NTIS as PB258322, $4.50.

Key words: head injury; helmets; math model; protective headgear; safety; test methods.

The purpose of this report is to outline the relationship between test methods for protective headgear and injury prevention. The state-of-the-art concerning the mechanisms of head injury and the relationship of these injuries to the modes of energy input are briefly reviewed. The general guidelines in the design of protective headgear are discussed, and the difficulties with present test methods for helmets are summarized.

In order to provide a quantitative framework, a simple model which incorporates many features of present test methods is defined and executed. The model predicts the effect of changes in test method parameters (headform, impact surface, drop height) for a range of helmet parameters. Among the indications suggested by the model are: 1) the occurrence of reversals in the order of helmet performance when the maximum acceleration is used as a performance measure, 2) the absence of reversals when biomechanical measures are used, and 3) the indicated suitability of compensating for the resiliency of the headform by the resiliency of the impact surface.

NBSIR 76-1109. **Architectural glazing safety standard: Survey of codes and standards,** S. C. Adler, 65 pages (Aug. 1976). Order from NTIS as PB257194, $4.50.

Key words: architectural glazing; codes; Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law.

The report describes 34 test procedures extracted from 97 codes and standards identified in an extensive library search of English language codes and standards relating to architectural glazing. The report also contains summaries of existing state laws relating to safety glazing. Test descriptions include procedures, kinetic energy levels, purpose of tests, and acceptance/rejection criteria. Test methods, codes and standards, and sources are cross-referenced.

NBSIR 76-1110. **The acoustic pressure field alongside a manikin's head with a view towards *in situ* hearing aid tests,** E. D. Burnett and G. F. Kuhn, 26 pages (Aug. 1976). Order from NTIS as PB257073, $4.00.

Key words: audiometry; diffraction; head diffraction; hearing aids; instruments for hearing; manikin.

To simulate actual usage conditions, the frequency response of hearing aids was measured on the head of a manikin over the frequency range of 0.2 to 8 kHz. The acoustic pressure around the head can vary rapidly as a function of frequency and location. In order to compare and interpret the hearing aid response at various frequencies and locations on the head, it is necessary to precisely know the pressure variations. The amplitude and phase of the acoustic pressure were measured in increments ranging from 2 mm to 5 mm alongside a manikin's head with frontal sound incidence. The acoustic driver was located in front of the manikin at a distance of 1.0 m from the ear canal axis. The test frequencies were the octave band center frequencies from 0.5 kHz to 4.0 kHz and the third octave band center frequencies from 4.0 kHz to 8.0 kHz. It will also be shown that pink noise of 6 percent and 29 percent bandwidth at 6.3 kHz and 8.0 kHz has a smoothing effect on the acoustic pressure variation with location.

NBSIR 76-1112. **Technical assessment of safety for hair dryer/stylers,** Y. C. Wu, 36 pages (Sept. 1976). Order from NTIS as PB259636, $4.00.

Key words: air flow rate; electrical, mechanical and thermal hazards; hair dryer/stylers; heat flux; safety; technical analysis; temperature.

The handheld dryer/styler is an efficient and popular small appliance, but a high injury trend associated with such products has been reported. Hazards commonly associated with the product are electrical, mechanical and thermal. In this study, the relation between these hazards and human tolerance limits were analyzed and experiments to investigate the probable cause and potential of such hazards were conducted. Randomly selected samples of the product were subjected to relevant safety performance tests of the UL Standard 859. In addition, air flow rate, heat flux and surface temperature were measured on several samples in order to determine their thermal hazard potential. Based on the results of these investigations, corrective measures are suggested.

NBSIR 76-1115. **Optical materials characterization,** A. Feldman, D. Horowitz, R. M. Waxler, and M. J. Dodge, 20 pages (Aug. 1976). Order from NTIS as PB257196, $3.50.

Key words: BaF_2; CaF_2; fused silica; interferometry; photoelasticity; piezo-optic constants; refractive index; thermal coefficient of refractive index; thermal expansion coefficient; ZnSe.

The refractive index of a sample of hot-forged CaF_2 was measured from 0.25 μm to 8.0 μm by means of the minimum-deviation method on a precision spectrometer. Data were obtained near 20 and 34 °C. Each data set was fitted to a three-term Sellmeier-type dispersion equation, which permits interpolation of refractive index as a function of wavelength within a few parts in 10^5. With the index values obtained at the two temperatures, the change in index with temperature was calculated. The refractive index and values obtained for this specimen are compared with data previously published. Two new experimental arrangements have been constructed for the interferometric measurement of the thermal coefficient of refractive index, thermal expansion, and piezo-optic constants. The first permits measuring dn/dT and thermal expansion from − 180 to + 200 °C. The second is a highly stable and sensitive interferometer for measuring photoelastic constants in the visible, the near infrared, and the near ultraviolet. Thermal expansion data are obtained on CVD ZnSe, CaF_2 and BaF_2 between − 100 and + 120 °C and fitted to a third degree polynomial in temperature. We obtain dn/dT for CVD ZnSe at 632.8 nm over the same temperature range. The piezo-optic constants of fused silica and CVD ZnSe obtained with the new interferometer at 632.8 nm are in excellent agreement with values obtained by other methods.

NBSIR 76-1120. **Fire research publications, 1975,** N. H. Jason, 17 pages (Sept. 1976). Order from NTIS as PB257837, $3.50.

Key words: bibliographies; building fires; construction materials; fire departments; fire detection system; fire tests; flame detectors; flammability tests; hazard analysis; interior furnishings; toxicity.

"Fire Research Publications, 1975" is a supplement to the previous editions which covered the years 1969-1972 (NBSIR 73-246), 1973 (NBSIR 74-511) and 1974 (NBSIR 75-736). Only publications prepared by the members of the Center for Fire Research (CFR), by National Bureau of Standards (NBS) personnel or external laboratories under contract or grant from the CFR are cited. Articles published in NBS house organs also are cited.

NBSIR 76-1124. **Evaluation system proposal preparation and evaluation procedure,** C. W. N. Thompson, 89 pages (Feb. 1976). Order from NTIS as PB261846, $5.00

Key words: evaluation systems; Experimental Technology Incentives Program; procurement experiments; procurement procedures; proposal evaluation procedures; proposal preparation procedures.

As part of its program with respect to the conduct of procurement experiments, the Experimental Technology Incentives Program of the National Bureau of Standards developed an integrated set of documents to provide information for use by both bidders and the proposal evaluation team in the procurement of two evaluation systems. The set of documents includes the following: (1) Introductory Notes; (2) Some Definitions; (3) Proposal Preparation Procedure

(with revisions); (4) Evaluation System Design Process; (5) Statement of Work; (6) Statement of Work (with illustrative subitems for Phase One); (7) Proposed Schedule—Overall; (8) Proposed Schedule—Phase One; (9) Proposal Evaluation Factors; (10) Proposal Evaluation Factors (with Illustrative Questions); (11) Numerical Weights for Proposal Evaluation Factors; and (12) Scope of Effort. Except for introductory and descriptive material, all of the documents are organized on the basis of seven factors (and thirty-three subfactors) to facilitate both preparation and evaluation of proposals. Each subfactor measures the bidder's understanding, present or proposed approach, and present or potential capability to perform with respect to an important problem or characteristic of the program. While the procedure is considered limited to certain systems and related procurements, it is considered a significant departure from prior procedures.

NBSIR 76-1126. **Field investigation of residential smoke detectors,** R. W. Bukowski, 53 pages (Nov. 1976). Order from NTIS as PB260878, $4.50.

Key words: detector sensitivity; detector siting; escape time; fire tests; heat detectors; residential fires; smoke detectors.

A test program was undertaken to evaluate the effect of sensitivity and placement of residential smoke detectors on their response to fires in homes. The tests were conducted in two homes scheduled for demolition and used actual furnishings in typical configurations. In addition to the detector response times, the homes were highly instrumented with data on smoke, temperature, and gas concentration measured for all tests.

The tests showed that smoke detectors can be highly effective in providing adequate warning of a fire before conditions in the home become dangerous.

NBSIR 76-1130. **Program and abstracts. Symposium on nonbiological transport and transformation of pollutants on land and water: Processes and critical data required for predictive description, May 11-13, 1976, National Bureau of Standards, Gaithersburg, MD,** L. H. Gevantman, Ed., 199 pages (May 1976). Order from NTIS as PB257347, $7.50.

Key words: adsorption; nonbiological transformation; nonbiological transport; pollutant photochemistry; pollutants; soil pollution; solar spectrum; water pollution.

Program, abstracts and extended abstracts of 21 papers presented at a symposium on nonbiological transport and transformation of pollutants on land and in water are documented. Most of the extended abstracts are detailed and contain figures and references to pertinent literature on the subject matter discussed at the symposium. The subject matter reviewed deals with the physical and chemical behavior of pollutants, including pollutant photochemistry, adsorptive behavior of pollutants, hydrolysis, rates of pollutants, and mathematical models for documenting pollutant behavior in soils and water.

NBSIR 76-1131. **A model performance standard for guardrails,** S. G. Fattal, L. E. Cattaneo, G. E. Turner, and S. N. Robinson, 31 pages (July 1976). Order from NTIS as PB259242, $4.00.

Key words: design; dynamic loads; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; static loads; stiffness; structural safety.

A model performance standard and design illustrations are presented for the design, construction and evaluation of guardrail systems, which will be used for the protection of employees against occupational hazards. The standard stipulates both structural and nonstructural safety requirements. Each criterion includes a commentary section describing the rationale used in its formulation. This rationale is for the most part, based on independent experimental and analytical research investigations conducted at NBS in behalf of OSHA.

NBSIR 76-1132. **Personnel guardrails for the prevention of occupational accidents,** S. G. Fattal, L. E. Cattaneo, G. E. Turner, and S. N. Robinson, 80 pages (July 1976). Order from NTIS as PB260363, $5.00.

Key words: anthropometric measurements; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; structural safety.

Existing information is compiled which would assist in determining structural and nonstructural safety requirements for guardrails used for the protection of employees against occupational hazards. Critical aspects of guardrail safety are identified through exploratory studies consisting of field surveys of prototypical installations, reviews of existing standards and industrial accident records, and compilation of relevant anthropometric data. These exploratory studies will be utilized to design an experimental program which will consist of structural tests to determine design loads and nonstructural tests to determine geometric requirements for guardrail safety.

NBSIR 76-1133. **Skid resistance measurement tests of FHWA reference systems at the Western Field Test Center,** R. W. Kearns and J. F. Ward, 167 pages (Oct. 1976). Order from NTIS as PB261228, $6.75.

Key words: accident reduction, skidding; correlation, skid resistance; highway safety; measurement, skid resistance; pavement, skid resistance; pavement wetting system; tire-pavement interface forces; wet pavement.

The Federal Highway Administration (FHWA) is developing a program to improve the method of measuring wet weather pavement skid resistance (SN) and to reduce the variation in results. At the national level, an interim reference system (IRS) is maintained and operated by the National Bureau of Standards. At the regional level, an area reference system (ARS) is maintained and operated at each FHWA field test center. Intercomparisons between these reference systems and the highway measuring systems at the state level, provide measurement assurance.

In this report, the first correlation results between the IRS and the Western ARS (WARS) are given: $SN_{WARS} = 4.55 + 0.99\ SN_{IRS}$ where the computed standard deviation of a mid-range predicted value is 1 SN. SN is described as a function of test speed, V, in mph (1 mph = 1.609 km/h): for surface 2; $SN(V) = 76.5 - 0.71 + 0.0070V^2$ and the speed gradient is $d(SN)/dV = -0.71 + 0.014\ V$.

The test program is explained from test preparations, tuning and calibration of subsystems, through dynamic measurement of the surfaces. Controlled and uncontrolled variables are identified, discussed, and in some cases, experimentally verified. A ranking of the sources of dispersion is given. A discontinuity in SN of surface 1 is identified due to the unique test plan. A ground station for improved SN calculation precision and on-site statistical analysis is found to meet design objectives.

NBSIR 76-1136. **Failure analysis of fiberglass insulator rods,** L. Mordfin and N. Halsey, 57 pages (July 1976). Order from NTIS as PB261965, $4.50.

Key words: breakdown, electrical; failure analysis; fiberglass-reinforced plastics; flammability; guy insulators; high-voltage tests; insulators, tower guy; Loran C; pultruded rods; rods, insulator.

Failure analyses were carried out on a group of coated fiberglass-reinforced-plastic insulator rods that had sustained burn damage and loss of coating in service on a radar tower. The investigation included chemical, flammability, electrical and mechanical tests as well as a

variety of measurements and inspections. The burn damage, consisting chiefly of carbonaceous tracking and charring, was attributed primarily to the occurrence of electrical discharges, from the energized end fittings to the rods, under conditions in which the electrical leakage path resistance had been reduced by moisture from rain, fog and ocean spray. The effects of this damage on the structural integrity of the rods were evaluated. Recommendations were made for reducing the incidence of such damage in the future, based on the use of skirted insulator rods or more effective coating materials. The principal cause of the coating loss was not positively identified. This form of damage was not found to have serious consequences except as a secondary factor which may have contributed to the occurrence of some partial electrical discharges.

NBSIR 76-1137. **Thermal data requirements and performance evaluation procedures for the national solar heating and cooling demonstration program,** E. Streed, M. McCabe, D. Waksman, J. Hebrank, and T. Richtmyer, 86 pages (Aug. 1976). Order from NTIS as PB257770, $5.00.

Key words: data requirements; measurement uncertainty; solar energy systems evaluation; thermal performance.

This report presents the results of a study to determine the data requirements and performance evaluation factors to be used in the National Solar Heating and Cooling Demonstration Program. Solar energy systems used for heating hot water, space heating, and space cooling have been considered and specific measurements and analytical procedures have been recommended to determine the thermal effectiveness for daily, monthly, seasonal, or annual operating periods. The sensor accuracy and sampling rate effects on measurement uncertainty for several performance factors is presented. Application of the individual performance factors for the comparison of subsystem and system thermal performance as a function of building type and climatic region is discussed.

NBSIR 76-1138. **A proposed experiment to evaluate environmental dependence of the measurement of noise from medium and heavy duty trucks,** C. I. Holmer and R. D. Kilmer, 68 pages (Sept. 1976). Order from NTIS as PB259522, $4.50.

Key words: acoustics; environmental conditions; noise measurement; noise (sound); transportation noise; truck.

Increasing concern with the impact of transportation noise on communities has led to an increase in the number of motor vehicle noise regulations at all levels of government. As regulations become more widespread, the accuracy and precision of vehicle noise measurements become more critical since each uncertainty in the measurement requires a corresponding increase in the margin that manufacturers must allow between the regulated noise limit and vehicle design levels. Although considerable uniformity has been achieved by existing voluntary standards, there remain significant variations between noise measurements made at different sites or at different times on the same site. These variations are attributable to differences in the environment, including site and meterological influences. Thus, there is a need for systematic investigation of the various environmental and test site effects on noise generation, radiation and/or propagation. This report presents the findings of a feasibility study for an experiment to investigate environmental effects on truck noise emission measurements. The result of this study is a proposed experiment designed to examine the systematic and nonsystematic dependence of observed truck driveby noise on the environmental effects present during the measurement. The experiment is designed in such a manner as to permit separation of emission and propagation effects. Although it may not be feasible to determine "correction factors" for environmental effects within the time and financial constraints of this experiment, it is fully expected that the data obtained from this experiment will reveal the magnitude of variations in the measurement and provide a broad enough information base for study of the underlying physical mechanisms.

NBSIR 76-1140. **Standards referenced in selected building codes,** B. M. Vogel, 447 pages (Oct. 1976). Order from NTIS as PB259626, $11.75.

Key words: building codes; building regulations; building regulatory system; standards.

This publication provides a compilation of the standards that are referenced in the building codes promulgated by: (1) the three model building code organizations; i.e., Building Officials and Code Administrators International, Inc. (BOCA); International Conference of Building Officials (ICBO); and the Southern Building Code Congress International, Inc. (SBCC); (2) the twenty States that have either mandatory or voluntary building codes; and (3) the thirty largest U.S. cities. In addition to identifying each standard referenced in the above named codes, this publication lists the current date of the standard, its current title, the codes referencing it, the date of the code, the locations within the code where the standard is referenced, and the date of the standard referenced in the code. This publication is intended to provide a base for assisting the building community in updating, utilizing and maintaining the standards referenced in building codes.

NBSIR 76-1141. **Study of initial stages of wear by electron channeling. I. Measurement of plastic strain in copper due to sliding wear, II. Quantitative methods in wear debris analysis,** A. W. Ruff, 53 pages (Sept. 1976). Order from NTIS as ADA031530, $4.00.

Key words: copper; electron channeling; electron microscope; metals; particle analysis; plastic deformation; surfaces; wear; wear debris; x-ray analysis.

Wear experiments have been conducted to determine the plastic strains that are introduced in the surface material near sliding wear tracks. Both oil lubricated and dry sliding experiments have been carried out at different sliding distances on surfaces of copper. The strain values were determined from selected area electron channeling patterns obtained using a scanning electron microscope from regions as small as 10 μm in size and 0.05 μm deep around the wear track. A deformed calibration specimen was used to relate electron channeling band contrast to deformation strain. Strain maps were obtained on the wear surface lateral to the wear track and also below the surface using electropolishing metal removal techniques. Particular attention was placed on the near-surface strain values. In all cases, the maximum strain was found at the wear surface located at the track center and the strains decreased uniformly with depth. Significant, large strains were also found outside the wear tracks. The results are compared with those previously reported for iron and with recent theoretical models.

Wear debris has been removed from a number of test systems and analyzed using different methods. Those methods produced specific information concerning the particulate size and composition. A magnetic debris recovery method was quantitatively evaluated using actual debris samples and also using collections of manufactured particulates having known sizes and compositions. Small 5 μm diameter SiO_2 spheres, some containing nickel, were used to simulate debris. Other particulates of iron and nickel in different size ranges were also used in order to investigate such matters as size resolution, lubricant dilution techniques, particle overlap difficulties, and the general problem of calibration of debris recovery systems. A comparison between chemical analysis and particulate analysis findings is presented. The application of optical and electron microscope methods and x-ray microanalysis in characterizing the wear particulates was carried out directly on the recovery substrate; those techniques are described.

NBSIR 76-1143. **Plan for the development and implementation of standards for solar heating and cooling applications,** D. Waksman, J. H. Pielert, R. D. Dikkers, and E. R. Streed, 55 pages (Aug. 1976). Order from NTIS as PB257769, $4.00.

Key words: buildings; solar energy; standards.

A plan is presented concerning the need, implementation and general scope of standards which may be required for solar heating and cooling applications. Overviews of the building regulatory system in the United States are given along with a listing of the various standards which will be required for the various solar systems, subsystems, components and materials. These include Test Method Standards, Recommended Practice Standards and Specification Standards. Activities relative to standards implementation include laboratory accreditation, certification, training and manuals of accepted practice. The development of standards for solar applications by the Federal Government are outlined, as well as the potential interface and utilization of the existing consensus standards generating organizations.

NBSIR 76-1144. **NBS interagency transducer project—Progress report No. 5,** J. S. Hilten, C. F. Vezzetti, J. F. Mayo-Wells, and P. S. Lederer, 26 pages (Nov. 1, 1976). Order from NTIS as PB259243, $3.50.

Key words: coatings; dynamic; dynamic response; pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; zero shift.

Experimental efforts are described in the development and evaluation of means to reduce the effects produced by thermal radiant-energy transients on pressure-transducer response. Both unbonded strain-gage and piezoelectric pressure transducers were used in this work with protective coatings applied directly to the diaphragms. The test method employed is to expose a pair of transducers—one protected and the other unprotected, but otherwise nominally identical—to a known radiant-energy transient with an energy density of approximately 20 mJ/mm^2. The resulting zero shift is measured and taken as an index of coating effectiveness.

The effect of the presence of the coating on transducer dynamic response was investigated by means of a shock tube, with a protected and an unprotected transducer pair exposed to the same pressure step of approximately 280 kPa (40 psi). Each transducer output was recorded as a function of time.

Test results with nine coatings and two transducer pairs are presented.

NBSIR 76-1147. **A combined least sums and least squares approach to the evaluation of thermodynamic data networks,** D. Garvin, V. B. Parker, D. D. Wagman, and W. H. Evans, 41 pages (July 1976). Order from NTIS as PB259637, $4.00.

Key words: computerized data analysis; data evaluation; least squares (L2); least sums (L1); thermochemistry; thermodynamic data networks.

A description is given of a system for computer-based evaluation of interrelated thermodynamic measurements of enthalpies of reaction, equilibria and entropies. This system is an extension of the CATCH program developed by J. B. Pedley, University of Sussex. In the new system linear least sums and least squares techniques are used to solve networks of thermodynamic equations to obtain the enthalpies and free energies of formation and the entropies of chemical substances. The least sums technique is shown to be useful in assessing the consistency of the data. A method combining least sums and least squares solutions, provides a weighted solution that reproduces closely the solutions that are obtained by a detailed analysis of the data using the customary sequential procedure. The results from tests on four large networks involving compounds of B, U, Rb and salts of Sn, Pb, Cd and Hg are discussed.

NBSIR 76-1153. **Microstructural aspects of deformation and oxidation of magnesia-doped silicon nitride,** N. J. Tighe, 11 pages (Sept. 1976). Order from NTIS as PB259638, $3.50.

Key words: cristobalite; deformation; electron microscopy; microstructure; oxidation; silicon nitride; slow crack growth enstatite.

The microstructural changes that occurred in magnesia-doped silicon nitride as a result of slow crack growth, plastic deformation and oxidation were studied by transmission electron microscopy. Specimens which exhibited slow crack growth showed extensive crack branching along the fracture path and ahead of the primary crack tip. These primary and secondary cracks followed intergranular paths. In samples which were deformed by bending at 1400 °C, dislocation arrays were found as well as intergranular cracks and voids. Silicon nitride oxidized during heating in air at 1400 °C and enstatite and cristobalite were present in the oxide layer. At lower oxidation temperatures, crystalline and amorphous silica formed a semiprotective layer on the silicon nitride surfaces.

NBSIR 76-1154, Vol. 1. **Consideration of fracture mechanics analysis and defect dimension measurement assessment for the Trans-Alaska Oil Pipeline girth welds,** H. Berger and J. H. Smith, Eds., 183 pages (Oct. 18, 1976). Order from NTIS as PB260400, $7.50.

Key words: fracture control; fracture mechanics; mechanical properties; nondestructive evaluation (NDE); radiography; welding.

In anticipation of a request for waivers on defective girth welds in the Trans-Alaska oil pipeline, DoT requested assistance from the National Bureau of Standards (NBS) in evaluating the fracture mechanics analysis and the nondestructive evaluation (NDE) methods used to detect and determine dimensions of weld defects.

NBS measured the required mechanical properties of the weld metal, developed and evaluated fracture mechanics methods to determine the allowable defect sizes, and evaluated various methods of measuring the size of defects present in the welds from existing field radiographs.

Results of this investigation show that the fracture mechanics analysis can be used to determine the allowable defect sizes concerning the integrity of the pipeline, but that these analyses have not been experimentally verified at this time. Defect dimensions can be determined with sufficient accuracy to be useful in the fracture mechanics analyses if the radiographs are made under carefully controlled conditions. If the radiographs are not made with close control, the accuracy of the defect sizes may not be sufficient to permit their use in establishing allowable defect sizes.

NBSIR 76-1154, Vol. 2. **Consideration of fracture mechanics analysis and defect dimension measurement assessment for the Trans-Alaska Oil Pipeline girth welds,** H. Berger and J. H. Smith, Eds., 135 pages (Oct. 18, 1976). Order from NTIS as PB260401, $6.00.

Key words: fracture control; fracture mechanics; mechanical properties; nondestructive evaluation (NDE); radiography; welding.

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perimentally verified at this time. Defect dimensions can be determined with sufficient accuracy to be useful in the fracture mechanics analyses if the radiographs are made under carefully controlled conditions. If the radiographs are not made with close control, the accuracy of the defect sizes may not be sufficient to permit their use in establishing allowable defect sizes.

NBSIR 76-1159. **Fatigue and weatherability studies of aramid-fiber rope slings,** N. Halsey and L. Mordfin, 35 pages (Sept. 1976). Order from NTIS as PB261994, $4.00.

Key words: aramid fiber rope; breaking load, rope; cable, aramid-fiber; end fittings, rope; fatigue damage; rope, aramid-fiber; slings, cargo; terminations, rope; weathering, simulated.

Tests were carried out on twenty-six sling-leg specimens, fabricated from aramid-fiber ropes, as part of a program to develop improved external cargo slings for helicopters. The ropes included both parallel-strand and cabled-strand varieties, in three different tensile capacities. The tests were intended to evaluate the reductions in rope strength caused by fatigue loading and by exposure to simulated weathering. It was found that the fatigue capabilities of some of the ropes may not be entirely satisfactory; but, because of inadequacies in the end fittings installed by the rope manufacturers, thorough evaluations were not possible. The results indicate that the performances of the ropes could be enhanced through the use of more efficient end fittings, and suggestions for the development of such end fittings are offered.

NBSIR 76-1162. **FY 1975-1976 international building research activities, Center for Building Technology,** S. G. Webber, 67 pages (Nov. 1976). Order from NTIS as PB260879, $4.50.

Key words: building research; cooperative programs; information exchange; international building research; international organization memberships; special foreign currency programs.

This report documents international building research activities of the Center for Building Technology (CBT) during Fiscal Year 1975 and 1976 (July 1, 1974-June 30, 1976). CBT carries out extensive interactions with foreign and international research organizations to exchange building research efforts. This report presents a summary of CBT's cooperative programs in building technology, international organization memberships, exchange programs, information exchanges, and foreign visits to NBS.

NBSIR 76-1172. **A new test method for automatic fire detection devices,** R. G. Bright, 29 pages (Dec. 1976). Order from NTIS as PB261217, $4.00.

Key words: fire detector; test methods.

An analysis of the test methods for automatic fire detection devices in the U.S. reveals the fact that different types and different sizes of fires are used to evaluate different classes of detectors. The result is a lack of comparison test data for each detector class and, as a consequence, intelligent decisions cannot be made in the selection of automatic fire detectors for specific fire risks. A new test method is proposed in which all automatic fire detectors, regardless of sensor type, would be subjected to a series of the same test fires. In addition, each test fire series would consist of three different test fire sizes. From the results obtained, it should then be possible to match a detector's characteristics against a specific fire risk resulting in a more intelligent application of automatic fire detectors.

NBSIR 76-1176. **Regional seminar on OMNITAB II,** D. Hogben and S. T. Peavy, 27 pages (Dec. 1976). Order from NTIS as PB261995, $4.00.

Key words: acceptance tests; AID; Bolivia; CENACO; computing using Spanish; foreign relations; international agreement; lectures; OMNITAB II computing system; technology transfer; terminals.

The authors visited La Paz, Bolivia, from May 11 to May 26 to conduct an AID Regional Seminar on applications of the OMNITAB II computing system. A Spanish, interactive version of OMNITAB II was implemented on the CENACO DEC-10 system computer. From May 17 to 22, lectures were given to thirty participants from five Latin American countries and sessions were held for the participants to gain experience in the use of OMNITAB II from terminals. At the beginning, the computer was not being used; at the end, OMNITAB II was being used extensively to solve important problems. An international agreement was signed by participants from the Latin American countries to cooperate in the utilization of computers.

NBSIR 76-1187. **Interim performance criteria for solar heating and cooling systems in commercial buildings,** 100 pages (Nov. 1976). Order from NTIS as PB262114, $5.50.

Key words: buildings; cooling; heating; hot water; performance criteria; solar energy; standards.

Public Law 93-409, the Solar Heating and Cooling Demonstration Act of 1974, provides for "demonstration within a three-year period of the practical use of solar heating technology, and .... the development and demonstration within a five-year period of the practical use of combined heating and cooling technology." Under the provisions of the Act, in February 1975, the NASA developed a first edition of this document containing interim performance criteria for the design and evaluation of solar heating and cooling systems to be demonstrated in commercial buildings. Since that time, responsibility for further development of the document has been assumed by the NBS. This second edition of the "commercial criteria" represents the first revision to the NASA document. It is expected that this document will be updated periodically as data and information are gained from the demonstration program.

NBS-GCR-73-1. **Characterization of bedding and upholstery fires,** C. A. Hafer and C. H. Yuill, 46 pages (Mar. 1970). Order from NTIS as PB192365.

Key words: bedding; beds; carbon dioxide; carbon monoxide; combustion products; fire gases; fire hazards; furniture; life hazard; oxygen; smoke; temperature; toxicity; upholstery.

Many accidental deaths are attributed to fires started from smoking in bed or in upholstered chairs. Frequently, the victims die as a result of exposure to smoke, heat, or noxious fumes that develop as materials burn rather than from skin burns. The objective of this program was to conduct full-scale tests using bedding and upholstered furniture to determine the life hazards that may be present during fires starting with a small ignition source.

Thirty individual tests were conducted using various combinations of materials. The ease of ignition of bedding and upholstery was demonstrated and the pattern of development of smoke, heat, noxious gases, and oxygen depletion was recorded.

NBS-GCR-73-2. **Fabric flammability test development,** W. R. Brown and F. A. Vassallo, 87 pages (May 1970). Order from NTIS as PB194614.

Key words: fabric flammability; flammability testing; heat transfer; smoldering fabrics.

Heat meter instrumentation and a test chamber are developed for the measurement of heat transfer from burning and smoldering fabrics. The meters yield a signal proportional to heat flux, and a four-channel electronic integrator provides total heat input data as a function of time. Literature data on skin damage vs. heat input are employed in a graphical overlay method of interpreting data in terms of skin damage. Data demonstrating good reproducibility in tests of cotton fabrics at various spacings are presented. Thermoplastic

fabrics tended not to burn or smolder regularly in the flat panel form employed in the test, but recommendations are given for study of strip specimens which may be amenable to test by the suggested methods. It was found that all of the fabric specimens which burned regularly in the chamber produced heat inputs at least double those required to inflict second-degree burns.

NBS-GCR-73-3. **Conversion of scientific and technical resources economic challenge—Social opportunity,** E. R. Mottur, 204 pages (Mar. 1971). Order from NTIS as COM 71-00605.

Key words: economic challenge; scientific and technical resources, converting; social opportunity.

This excerpt from the forthcoming overall project report describes the economic challenge and social opportunity presented by conversion of scientific and technical resources, and sets forth 26 policy proposals as a national program for conversion.

The report is concerned solely with conversion of the nation's scientific and technical resources, including manpower (scientists, engineers, technicians, support personnel, and technical management), facilities and equipment, and scientific and technical information. Conversion of scientific and technical resources from the defense sector must be to civilian R&D aimed at ameliorating national social problems.

Need for Conversion: About 100,000 scientists, engineers, and technicians are currently unemployed. About 200,000 (one out of ten technical personnel in the nation) are likely to be unemployed by the end of 1971.

Need for National Program: Report contends conversion can succeed only through cooperation of Federal, State, and local governments, with private industry, universities, and the scientific and technical community; with strong federal leadership.

Existing conversion programs and proposals are reviewed and characterized as essentially job-placement activities. Conversion bills pending in Congress are also analyzed.

NBS-GCR-73-4. **The influence of fine structure on the pyrolysis and combustion of cellulosics,** M. Lewin and A. Basch, 62 pages (1972). Order from NTIS as COM 73-10323.

Key words: cellulosic fibers; combustion; cotton fibers; flame retardant treatments; phosphorous acids; pyrolysis; ramie; rayon; sulfur.

A series of cellulosics comprising cottons, ramies and rayons differing in degrees of crystallinity and orientation were purified, characterized and pyrolyzed in vacuum and in air at low and high temperatures. The kinetics of the low temperature pyrolyses were studied and activation energies were derived by dynamic TGA. The rates of the low temperature pyrolyses in both vacuum and air are shown to be dependent upon the crystallinities and orientations of the cellulosics. In addition, the rates of vacuum pyrolysis are also a function of the D.P., while the rates of air pyrolysis are influenced by the crystallite accessibility. A novel IR technique was developed which indicates that levoglucosan formation during combustion is also a function of crystallinity and orientation. A correlation was found between energies of activation and cellulose crystallinities which suggests that the measured values are the sum of separate contributions from the crystalline and less-ordered regions. Cottons, rayon and ramie were given a variety of flame-retardant treatments with reagents containing either sulfur or phosphorous as the principal flame-retardant component.

NBS-GCR-73-5. **National fire data system, system design project, final report,** 175 pages (Mar. 9, 1973). Order from NTIS as COM 73-10951.

Key words: design criteria; fire hazards; fire losses; fire reporting; fire safety; information systems; National Fire Data System; specifications; state governments; systems analysis.

The design for a multi-file National Fire Data System is described. Data concerned with fire incidents, deaths, injuries, and fire loss will be collected from the fire service, the insurance industry, health service organizations, and a number of special sources. A time-sharing computer center will be utilized through remote terminals to store, manipulate, and aid the reporting of the collected data. Input consists of a series of specified reports from designated data suppliers of a number and type to provide statistically valid coverage for national projection purposes. Each type of input will be stored as a separate system file. The Auerbach report describes the data sources, the proposed processing facility including staffing requirements, probable outputs, and data base specifications; the procedures for data acquisition, encoding, data preparation, data base maintenance, and quality control; and a plan for implementing the system.

NBS-GCR-73-6. **A study of preignition heat transfer through a fabric-skin system subjected to a heat source,** G. Heskestad, A. S. Kalelkar, and H. C. Kung, 53 pages (Dec. 1971). Order from NTIS as COM 73-10959.

Key words: apparel fabrics; fabrics; fire hazards; flammability testing; ignition; skin; thermal burns; thermal measurements.

Theoretical and experimental studies of preignition events transpiring in fabric-skin systems upon exposure to a radiant heat source are reported. Particular emphasis is placed on determining relationships between time to ignition of the fabric and time to pain in the skin of the fabric wearer which allows assessment of probabilities of ignition. Several common fabrics are ranked in order of decreasing safety as the pain time increases relative to the ignition time and evasive action by the fabric wearer becomes less and less effective.

NBS-GCR-73-7. **Study of ignition and exposure,** L. Fourt, 52 pages (Dec. 31, 1971). Order from NTIS as COM 73-10958.

Key words: apparel fabrics; fabrics; fire hazard; flammability testing; ignition; thermal burns.

Simulated sleeves were exposed to a gas range burner, and the time to ignition determined. For cottons and polyester/cellulose blends, the ignition time was proportional to fabric weight, except for napped flannel and terry cloth which ignited rapidly for their weight. Woven and knit fabrics were similar. Nylon and polyester and, in some cases, acetate, shrunk away from the flames unless seams sewn with cotton thread were exposed.

NBS-GCR-73-8. **A study of hazards from burning apparel and the relation of hazards to test methods,** A. Alkidas, R. W. Hess, W. Wulff, and N. Zuber, 208 pages (Dec. 1971). Order from NTIS as COM 73-10954.

Key words: apparel fabric; fabric; fire hazard; flammability testing; thermal measurements; thermodynamic properties.

The following thermal properties of a selected set of cotton, nylon, polyester, acetate, and blend fabrics were measured: thermal conductance, specific heat, ignition or melting temperature, infrared reflectance and transmittance, activation energy, reaction enthalpy, and ignition time under radiative fabric heating. Detailed distributed-parameter ignition models and simplified analyses based on lumped-parameter models were considered, and seven characteristic groups established which govern the heating and reaction processes. Experimental and theoretical results were compared.

NBS-GCR-73-9. **Study of hazards from burning apparel and the relation of hazard to test methods: Flammability of clothing assemblies,** J. F. Krasny and A. L. Fisher, 50 pages (Jan. 19, 1972). Order from NTIS as COM 73-10953.

Key words: apparel fabrics; fabrics; fire hazard; flammability testing; skin; thermal burns; thermal measurements.

The objective of the project was to estimate the area of the body burned and the depth of burn as a function of the garment assemblies worn by clothing fire victims. Such fires were modeled by burning garment assemblies on mannequins covered with temperature indicators; the temperature indicator measurements were correlated with depth of burn into the skin of rats. Chimneys on garments were found to increase very significantly the area of the mannequin raised to elevated temperatures in a given time from ignition; belts tended to act as fire stops. Tighter fit of dresses appeared to cause higher mannequin temperatures, but direct contact of dress and mannequin slowed down fires. Thermoplastic (nylon and polyester) dresses and fire retardant cotton dresses did not ignite in these experiments unless combined with a flammable slip, though the area of potential injury in such combinations was relatively small. Similar areas were raised to elevated temperatures by burning polyester/cotton dresses with or without polyester/cotton slips, but nylon slips seemed to reduce the area.

NBS-GCR-73-10. **Firefighters' breathing system study,** 171 pages (Apr. 1972). Order from NTIS as COM 73-10952.

Key words: breathing apparatus; closed loop breathing apparatus; equipment design; fire fighters; fire fighting; fire fighting equipment; fire gases; open loop breathing apparatus; protective clothing; smoke inhalation; standards.

This report is the result of a study to produce research and development plans for each of three types of firefighters' breathing support equipment. The three design types are the open loop, the semiclosed loop, and the closed loop. The study identified the improvements possible for each design type. This report includes the recommended improvements and lists the time and cost likely for each development.

In addition to the recommendations and development plans for breathing systems improvement, the report includes sections of specifications, breathing gas sources, materials, and other significant elements of the breathing systems. To support the development plans, there are also recommendations for needed laboratory and engineering studies.

NBS-GCR-73-11. **Study of hazards from burning apparel and the relation of hazards to test methods,** O. A. A. Naveda, P. Durbetaki, P. T. Williams, W. Wulff, A. Alkidas, E. R. Champion, W. E. Giddens, R. W. Hess, and B. Kumar, 274 pages (Dec. 31, 1972). Order from NTIS as PB242597.

Key words: apparel, burn injuries; burn injuries, fabric related; burning apparel; fabric related burn injuries.

It was shown that the hazard from fabric-related burn injuries can be quantitatively assessed in terms of the probability that such injury is suffered. This probability depends upon the probabilities associated with the possible events leading to the injury, such as ignition after exposure combustion after ignition and tissue decomposition during and after burning. It was also shown that the probability of fabric ignition under given exposure depends on the ratio of fabric ignition time to exposure time; hence that the ignition time is an important characteristic required to assess the hazards of fabric-related burn injuries.

NBS-GCR-73-12. **Ease of ignition of fabrics exposed to flaming heat sources,** G. Heskestad, 113 pages (Jan. 1973). Order from NTIS as COM 73-10955.

Key words: apparel fabrics; fabrics; fire hazards; flammability testing; ignition; thermal burns; thermal measurements.

The ease of ignition of fabrics exposed to flames was studied. Ignition or melting times were at a minimum close to the luminous tip of diffusion and to the tip of the inner cone of premixed flames. These minimum ignition times were found to be insensitive to fabric orientation, burner tube diameter, and flame height but varied appreciably for diffusion and premixed flames. With the exception of fabrics with prominent surface structures (e.g., terry cloth), ranking of fabrics by ignition and melting times would be preserved through a large number of exposure modes. A simple theoretical model, which considers the fabric to be impervious and inert, to possess a unique ignition temperature, and to be heated solely by convection, is consistent with the experimental findings. Fabric variables found to be of importance were the fabric weight, average specific heat over the heating interval to ignition and the ignition temperature. Porosity, humidity, proximity to a skin simulant, and weave (except structures like terry cloth) were less important: Flame source variables of importance are the temperature and velocity at the tip, and possibly the diameter of the gas plume at the tip.

NBS-GCR-73-13. **Hazards from burning garments,** G. Arnold, A. Fisher, and G. Frohnsdorff, 85 pages (Mar. 26, 1973). Order from NTIS as COM 73-10957.

Key words: apparel fabrics; fabrics; fire hazard; flammability testing; simulation; skin; thermal burns.

Experiments were carried out to determine the area of the body burned, and the depth of burn likely to be suffered by clothing fire victims as a function of the garment worn, by burning full clothing assemblies on mannequins. It was found that single layer dresses made from nylon, polyester, Nomex, and flame retardant cotton fabrics self-extinguished and could be assumed to cause no injury; single layer dresses of cotton burned somewhat faster than similar weight polyester/cotton blends but the total heat transferred was similar; double layers consisting of dress and slip burned if at least one of the layers was a fabric which would burn in a single layer. The rate of burning and the heat transferred depended on the fabrics used as the dress and the slip; the use of a belt with dresses at least slightly reduced the initial rate of burning and the total heat transferred to the mannequin; all garment combinations which burned transferred sufficient heat to the mannequin to cause second degree and deeper burns, with the greatest burn depth usually on the lower region of the torso.

NBS-GCR-73-14. **Measurement of flammability and burn potential of fabrics, summary report, December 1, 1970-November 30, 1971,** A. K. Mehta and F. Wong, 69 pages (Feb. 15, 1973). Order from NTIS as COM 73-10950.

Key words: apparel fabrics; fire hazard; flammability testing; heat conductivity; simulation; skin.

The objective of this work was to study local skin burn damage due to burning apparel fabrics. Three skin simulants were constructed: two copper-air rod systems simulating the thermal properties of skin with a large depth stretch factor; and one system without depth magnification. Twenty apparel fabrics were burned in the horizontal, 45°, and vertical positions, in the latter two cases with the flame traveling up and down. The injury potential of each fabric was then evaluated.

NBS-GCR-73-15. **Measurement of flammability and burn potential of fabrics,** A. K. Mehta and F. Wong, 331 pages (Feb. 15, 1973). Order from NTIS as PB242582.

Key words: burn, fabric; fabric, burn; flammability.

Two types of inanimate materials having the average thermal properties of human skin were studied. The thermal properties of both types of skin simulants, which were checked by exposing them to known radiant fluxes and monitoring the temperature response, were found to agree closely with the design values.

A set of twenty different fabrics, widely used in apparel, were tested. The depth of thermal damage was found to increase approximately linearly with increase in the total thermal dose to skin, for the exposure times and the magnitudes of the heat fluxes involved in these specific fabric burning experiments. This finding indicates the possibility of rating the burn damage potential of fabrics, crudely, by

only two measurements, namely flame spread rate and total thermal damage to skin.

Measurements of the heat transfer rates from the leading edge to the fuel were conducted with the flame spread burner. These experiments indicate that about 2/3 of the preheat energy is delivered ahead of the leading edge of the flame while the highest intensity of energy is confined to a small region under the flame extension.

NBS-GCR-73-16. **Status and prospects for flame resistant polyester/cellulose blend fabrics,** G. C. Tesoro, 56 pages (Mar. 15, 1973). Order from NTIS as COM 73-11265.

Key words: cotton; fabrics; flame retardants; flammability; phosphorus; polyester; rayon; treatments.

This report describes the status of flame retardant finished polyester/cotton and polyester/rayon blend fabrics. While these fabrics represent a large part of the present market, there exists presently no commercial flame retardant treatment for them, though such treatments are available for 100 percent cellulose and 100 percent polyester fabrics. Self-extinguishing behavior can be attained by insolubilizing sufficient phosphorus on the blends, and the amount of phosphorus needed is lowered by the presence of bromine. Phosphorus in the form of phosphine oxide, derived from treatment with tetrakis-hydroxymethyl phosphonium derivatives, has been shown to be more effective than phosphonate or phosphoramine phosphorus. The amount of finish necessary to obtain self-extinguishing behavior, however, tends to stiffen the fabric and raises its cost. Suggestions are made for further research in this area.

NBS-GCR-73-17. **A candidate standard for fundamental BASIC,** J. A. N. Lee, S. R. Bechhardt, and A. I. Karshmer, 148 pages (Oct. 19, 1973). Order from NTIS as COM 74-10932.

Key words: ADP standards; BASIC; compilers; compiler validation; computer programming; formal language; programming language standards.

Under contract to the National Bureau of Standards, a candidate standard specification and supporting analyses have been developed for a nucleus or fundamental subset of the BASIC programming language. This report, in four parts described below, will be immediately considered for Federal standardization, and is intended also to assist national standardization efforts. Part 1: *Standard Specifications for BASIC.* This specification establishes the form and the interpretation of programs which are written in the BASIC language, for the purpose of promoting a high degree of interchangeability and transportability of such programs among automatic data processing systems. Part 2: *Explanations, Examples and Recommendations.* This part provides explanations, examples, and recommendations which are additional to, but not part of the BASIC specifications. Part 3: *Programs for the Validation of BASIC Implementations.* The BASIC programs contained herein provide a set of routines for the testing and validation of BASIC language implementations. Part 4. *Formal Description of BASIC.* The formal description of BASIC is composed of three parts: the concrete syntax, the abstract syntax, and a semantic description of the operational meanings of the elements of the program.

NBS-GCR-73-18. **Source mechanisms of microearthquakes associated with underground mines in Eastern Utah,** R. B. Smith, P. L. Winkler, J. G. Anderson, and C. H. Scholz, 46 pages (Oct. 1973). Order from NTIS as COM 73-11783.

Key words: acoustics; coal; earthquakes; geologic faults; mining; tectonics.

A detailed microearthquake survey, with acoustic monitoring, was conducted in the Sunnyside coal district of eastern Utah to investigate the possible relationship between earthquakes and mining. Rates of earthquake activity averaged hundreds of events per day with magnitudes from -0.5 to $+2.0$. The zone of greatest earthquake activity was centered 1 km beneath a portion of the mine which exhibited floor and roof failures. A composite fault plane solution for the main zone of activity defines reverse faulting with nodal planes striking N15°E. The P axis has an azimuth of N75°W and dips 25°W. This is in agreement with the general stress pattern attributed to the tectonic development of the nearby San Rafael Swell and suggests that the main earthquake energy may be derived from regional tectonic stress. Acoustic emissions recorded within the mine showed an average rate of 180 per hour and appear to be due to shear failures near the mine walls. The rate of acoustic activity decreased with time after the latest mining activity. Spectral analyses of direct shear waves from the sub-mine quakes yielded estimates of source parameters at hypocentral distances from 1.3 km to 3.0 km. The data are in agreement with the results of other work and extend the previous studies of source spectra down to magnitudes less than $+1$ for short hypocentral distances.

NBS-GCR-73-19. **Regulation and evaluation of industrialized building: A literature review with annotated bibliography,** J. N. Thompson and C. T. Grimm, 60 pages (Dec. 1973). Order from NTIS as COM 74-10481.

Key words: building codes; building laws and regulations; building materials—testing and evaluation; building systems; industrialized housing; mobile homes; modular construction; prefabrication; zoning.

This review, annotated bibliography and index covers literature published in the English language on the regulation and evaluation of industrialized building. The scope of the review includes the period from 1940 to April, 1972.

A summary of the literature precedes the review. The summary follows the subject divisions used in the review.

The review is divided into two parts, titled "Regulation" and "Evaluation." The first part deals with methods used to regulate industrialized housing, including: building codes (local, state, and model); standards; and zoning. The second part deals with the methods used to evaluate industrialized housing, including administration of the evaluation process. Each section of the review presents the literature in chronological order in an attempt to show the development of attitudes, trends, and accomplishments affecting the progress of industrialized housing.

The annotated bibliography is divided into subject sections which correspond to those used in the review. Key words are included for each bibliographic entry. For reference purposes, a comprehensive index includes subjects, authors, and titles cited in the literature review and annotated bibliography.

NBS-GCR-73-21. **Research study on the socioeconomic aspects of low-cost housing in the Philippines,** 149 pages (May 1972). Order from NTIS as COM 74-10722.

Key words: construction; design; developing countries; earthquakes; low-cost housing; natural disasters; Philippines; socioeconomic aspects; typhoons.

The report presents a survey of the historical occurrence of damages by typhoons, selected comparative indices for climate and housing construction, an economic profile of the Philippines, as well as a regional demographic profile. A discussion is also presented on size and density of household dwelling units, trends in housing space expansion, community and municipal facilities; household income and household expenditures; financing sources for housing construction; availability and prices of construction materials and of labor; the capabilities of the housing industries; public reaction to new designs and materials; methods of housing construction and building codes.

NBS-GCR-74-22. **Mechanical and acoustical signature analysis of engine-generator units to be used at the Department of**

Housing and Urban Development Total Energy Plant, Jersey City, New Jersey, R. F. Burchill, 374 pages (May 1973). Order from NTIS as COM 74-10934.

Key words: diesel-electric sets; gears; looseness; signature analysis; unbalance; vibration.

This report summarizes the acoustical vibration and stack gas temperature and conditions of each of five diesel-electric sets tested in the vendor's factory. The data in this report was collected simultaneously with fuel, cooling water and electrical transient data during the factory acceptance tests. The tests were supervised by NBS staff and were required by the purchase specifications. The purchase specifications were based upon a total energy performance specification developed by NBS for this project (A Performance Specification For A Total Energy Plant At The Jersey City Breakthrough I Site, NBS Report No. 10313, December 29, 1970). Signature analyses of each engine over the test load range were calculated and plotted. The signature analyses show machinery unbalance rotating component looseness, ball and roller bearing deterioration and gear damage or wear.

These signature analyses are baseline data which will be compared with signature analyses taken at future dates as the engines age. Changes in the signature analysis will be used to predict required maintenance services.

NBS-GCR-74-23. **Survey of lube oil analysis techniques to be used at the Department of Housing and Urban Development Total Energy Plant, Jersey City, New Jersey,** 21 pages (Sept. 1973). Order from NTIS as COM 74-10929.

Key words: chip detectors; ferrograph; lube oil analysis; magnetic drain plugs; oil filters; oil monitors; particle detectors; spectrograph.

Lube oil analysis can be an important consideration in the preventive maintenance program of diesel-engine-generators which provide prime power to a housing site. This report surveyed possible lube oil monitors that would scientifically "inform" plant operators when oil needed changing rather than changing the oil after a fixed amount of operating hours.

Several lube oil monitors are discussed. Filter check is used for aircraft gas turbine oil analysis; however, in diesel engines, the presence of combustion products requires a high level of detective skill. Magnetic drain plugs are useful but a failing gear may only show a small amount of ferrous particles while normal wear from cylinder liners, etc. produces large amounts of ferrous particles. Other monitors discussed are: chip detectors, oil particle detectors; spectroscopic oil analysis and ferrograph techniques.

The report recommends that samples of the lube oil be regularly spectroscopically analyzed for wear particles and lubricant degradation. The report also recommends the engine lube oil systems be setup so that other types of lube oil monitors can be used.

NBS-GCR-74-24. **Development of a test for impact protection,** J. M. Akridge, W. J. Freeston, Jr., W. L. J. Leverett, W. D. McLeod, M. K. Rao, and W. Wullff, 78 pages (Apr. 1973). Order from NTIS as COM 74-10983.

Key words: energy absorption; impact test; protection; protective equipment.

An Impact Test Apparatus has been designed and testing procedures have been proposed to measure systematically on flexible, semi-rigid and rigid impact protection systems their abilities to absorb kinetic energy and to distribute peak impact pressure away from the point of impact.

The proposed impact simulation is based on impact descriptions extracted from the findings of an intensive literature search on impact injuries, primarily car crash impact studies.

An impact modeling analysis was performed and solutions are presented. Modeling parameters and procedures for experimental impact data evaluation have been derived from the analysis.

A multitude of impact modes on practically all parts of the human body, namely skull, torso, leg and arm, have been included in the impact simulation. The proposed versatile Impact Test Apparatus is considered to be a research tool which is needed for the fundamental work that could lead to simple standard test methods for specific impact situations.

NBS-GCR-74-25. **Use type tests for comfort and effectiveness of firemen's turnout coats,** N. R. S. Hollies, L. Fourt, G. A. Arnold, and N. Custer, 129 pages (May 1974). Order from NTIS as COM 74-11075.

Key words: clothing; firemen's turnout coats; use type tests for comfort and effectiveness.

This report describes five tests involving the interaction between a fireman's turnout coat and the fireman working in it. The amount of replication necessary to establish major recognizable differences in present designs is ascertained, together with the standard deviation of typical groups of measurements. The man-hours of subjects and observers required to carry out such comparisons are reported. The tests include the metabolic cost of clothing, rate of mixing of air in spaces inside the coat with outside air, thermal insulation of clothing while being worn, effect of clothing on sweat production and evaporation, and the water uptake by clothing worn under the spray of a fog nozzle.

NBS-GCR-74-26. **Planning computer compatibility for uniform building regulation documents; final report; advanced information systems,** J. Eberhard, T. Tiedeman, and C. Green, 106 pages (May 1973). Order from NTIS as COM 74-11633.

Key words: automatic data processing; building codes; building regulations; computer applications; computers; enforcement; evaluation; information systems; microfilm; microform; state-of-the-art study.

This report provides an introduction to the use of Automated Data Processing (ADP) and microform systems in the administration and enforcement of building regulation, particularly relating to factory manufactured buildings and mobile homes. The focus of the report is to make the reader aware of the planning considerations which must be dealt with when use of these information handling systems is contemplated. A background knowledge of building regulatory functions is assumed of the reader, but not technical knowledge of ADP or microform. Topics covered include: 1. Basic introduction to ADP and microform use. 2. State-of-the-art examples of microform use in building regulation. 3. State-of-the-art examples of computer use in building regulation. 4. Basic planning guidance for ADP and microform use. 5. Potential building regulatory use areas for ADP and microform. 6. Selected references.

NBS-GCR-74-27. **State-local interface relationship in the regulation of manufactured building,** 102 pages (Oct. 1974). Order from NTIS as COM 75-10143.

Key words: building codes; factory-built housing; industrialized building; inspection; manufactured building; model codes; model documents; NCSBCS; on-site construction; prefabricated construction; standards; state-local relationship; state regulations.

A key element in the statewide regulation of manufactured building is the state-local interface relationship. This study sought to isolate existing interface problems and to provide recommended solutions. Problem analysis and solutions presume a regulatory framework drawn along the lines suggested by the proposed Model Manufactured Building Act and Coordinated Evaluation System Documents. Inadequacies in the legislative areas coupled with the

lack of a well defined communication system constitute the prime interface problems. Suggestions for legislative changes, including revisions to the Model Act, are presented in this report together with recommendations designed to achieve better communications. Results of the data collection and analysis of existing state legislation are included.

NBS-GCR-74-28. **Study of teletypewriter interface and communications standard. Volume I,** 265 pages (Jan. 16, 1967). Order from NTIS as PB176912.

Key words: alphanumeric symbols; AUTODIN (Automatic Digital Network); JOSS; keyboards; MAC project.

The final report consists of two volumes. The first volume (PB176912) contains the results of the investigations of existing standards, teleprinters, modems, multiplexors, and data processors, and the systems in which they are used. The second volume (PB176913) contains the Formulation and Recommendations of Factors for Standardization.

NBS-GCR-74-29. **Study of teletypewriter interface and communications standard formulation and recommendation of factors for standardization. Volume II,** 69 pages (Jan. 16, 1967). Order from NTIS as PB176913.

Key words: acceptability; coding; costs; data transmission systems; decisionmaking; economics; errors; information theory; input-output devices; interfaces; malfunctions; man-machine systems; remote control systems; systems engineering; state-of-the-art reviews.

The final report consists of two volumes. The first volume (PB176912) contains the results of the investigations of existing standards, teleprinters, modems, multiplexors, and data processors, and the systems in which they are used. The second volume (PB176913) contains the Formulation and Recommendations of Factors for Standardization.

NBS-GCR-74-30. **Study of teletypewriter interface and communications standards. Task 1. Review of previous standardization programs and existing standards,** P. J. Mellett, 43 pages (Sept. 15, 1966). Order from NTIS as COM 74-11732.

Key words: coding; interfaces; modems; signal processing; standards; teletypewriters.

The report discusses previous and existing standards for the interfaces between data processing equipment and communications systems.

NBS-GCR-74-31. **Study of teletypewriter interface and communications standards. Task 3. Review and comparison of communications terminal equipment of common carriers and other suppliers,** P. J. Mellett, 25 pages (Sept. 30, 1966). Order from NTIS as COM 74-11733.

Key words: common carriers; computer networks; interfaces; modems; telecommunication.

Interface between the communications line and the data processing equipment is provided by line termination equipment. The function of this equipment is to change the digital pulses of the data processor into signals suitable for transmission over telegraph or telephone channels. This type of equipment is usually referred to as a MODEM (modulator-demodulator). Generally, this equipment is available through the common carriers on a lease basis as part of their communication services. There are some commercial suppliers of such terminal equipment, which is generally used in conjunction with private or military communications networks. This task consists of comparing the available communication line terminals that are suitable for coupling teletypewriter equipment and computer multiplex units to communication lines for speeds less than 300 baud. The various units are discussed and are presented on a comparison chart (appended to report), so that corresponding parameters for each equipment may be directly compared.

NBS-GCR-74-32. **Design concepts for safer matches and lighters,** 60 pages (Sept. 29, 1972). Order from NTIS as COM 75-10039.

Key words: burns; fabric fires; fire injuries; flammable fabrics; ignition hazards; ignition sources; lighters; matches.

A match or cigarette lighter is frequently the source of ignition in fires involving the accidental burning of fabric items. Consequently, any design of book matches or lighters which would contribute to their utilization in a safer manner would be highly desirable.

In this report, eight design modifications for book matches and seven modifications for cigarette lighters are described and discussed. The objective of the new designs is to prevent the accidental ignition of clothing or other fabric material when used by children in a play situation or when used for a bona fide application by the adult population. The designs proceeded from a study of ignition sequences gleaned from accident reports filed with the National Bureau of Standards.

Emphasis was placed on developing a safer match design for the protection of the very young, the 0-10 age group. The judgments of the investigators, when applied to a devised rating system, indicated the following: (1) A matchbook designed with a sleeved striker which requires insertion of a thin match and coordinated action of both hands, is the most promising; (2) A lighter concept which utilizes a screened flame is considered the most desirable. Other designs also show a reasonable degree of improvement and it is a conclusion of this report that one or more of the designs described, if adopted, will lead to increased safety for the entire population.

NBS-GCR-75-33. **Impact noise testing and rating,** T. J. Schultz, 245 pages (Dec. 1974). Order from NTIS as COM 75-10133.

Key words: acoustics; building acoustics; impact noise; noise; structural vibration.

This report presents a review of the historical development of and the current state-of-the-art in testing and rating floor/ceiling building construction assemblies with respect to their capability for isolating against annoying impact noises. This review was prepared in order to identify the technological basis underlying the current state-of-the-art and the relevant analytic and experimental methods. Recommendations for future research directed toward the evolution of improved standard test procedures are presented.

NBS-GCR-75-34. **Dynamics of textile fires,** G. H. Markstein and J. deRis, 54 pages (Mar. 1974). Order from NTIS as COM 75-10128.

Key words: edges; fabric construction; fabric flammability; fire spread; flame spread; flame spread rate; surfaces; textiles.

This report is concerned with fire spread rates over the surface and along the edge of textile fabrics and their controlling mechanisms. In a previous study, upward two-dimensional turbulent fire spread was investigated using side-walls to prevent sideways air entrainment. This resulted in a continuously accelerating flame spread over heights of practical interest. In the present study, three dimensional flow was permitted by eliminating the side walls. The resultant flame spread becomes steady soon after ignition. There is evidence for some correlation between the various tests: (1) the small scale 45° upward-burning test (CS 191-53); (2) Miller's measurements on his rotating drum apparatus; (3) our realistic-scale upward turbulent spread; (4) our edge-spread data; and finally (5) the fundamental downward creep spread. The large scale upward spread experiments tend to emphasize the chemical composition differences of fiber materials due to enhanced radiation from the larger flame while the smaller scale tests emphasize fabric construction differences due to the closer similarity of flame and fabric detail length scales.

NBS-GCR-75-35. **Characterization of pavement macrotexture by profile spectral analysis,** J. M. Lawther and J. J. Henry, 93 pages (June 1974). Order from NTIS as COM 75-10341.

Key words: noise; pavement macrotexture; profile tracer; tires.

This report presents the results of a study by the Pennsylvania State University to demonstrate the feasibility of utilizing a profile tracer to measure pavement macrotexture. Four test pavements—part of the Pennsylvania Transportation Institute Skid Test facility—were measured and spectrum analysis plots of the pavement profiles are presented. In addition, space frequency spectrum analyses of the profiles were generated and site-to-site comparisons were made. The results are presented in terms of their potential relationship to tire noise.

NBS-GCR-75-36. **Methodology for hazard evaluation of buildings, Vol. I: Technical report,** J. H. Wiggins, G. C. Hart, T. Hasselman, and R. W. White, 353 pages (Dec. 1973). Order from NTIS as PB261144.

Key words: buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural disasters and to estimate the amount of expected damage. Damage to both structural and nonstructural building components resulting from the extreme environments produced by earthquakes, hurricanes, and tornados is considered. The methodology is capable of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. The procedure for the methodology is based on a computer analysis of the entire structure and is based on the current state-of-the-art. Numerical examples illustrating applications of the procedure are included.

NBS-GCR-75-37. **Methodology for hazard evaluation of buildings, Vol. II: Computer program users manual,** T. K. Hasselman, R. W. White, and G. Brandow, 112 pages (Dec. 14, 1973). Order from NTIS as PB261145.

Key words: buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural disasters and to estimate the amount of expected damage. Damage to both structural and nonstructural building components resulting from the extreme environments produced by earthquakes, hurricanes, and tornados is considered. The methodology is capable of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. The procedure for the methodology is based on a computer analysis of the entire structure and is based on the current state-of-the-art. Numerical examples illustrating applications of the procedure are included.

NBS-GCR-75-38. **Methodology for hazard evaluation of buildings, Vol. III: Demonstration report,** J. H. Wiggins, G. C. Hart, and R. W. White, 76 pages (Dec. 1973). Order from NTIS as PB261021.

Key words: buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural disasters and to estimate the amount of expected damage. Damage to both structural and nonstructural building components resulting from the extreme environments produced by earthquakes, hurricanes, and tornados is considered. The methodology is capable of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. The procedure for the methodology is based on a computer analysis of the entire structure and is based on the current state-of-the-art. Numerical examples illustrating applications of the procedure are included.

NBS-GCR-75-40. **Polymer flame retardant mechanisms,** D. J. Holve and R. F. Sawyer, 34 pages (Feb. 1975). Order from NTIS as COM 75-10696.

Key words: fire retardant mechanisms; fire retardant polymers; fire retardants; mass transfer number; opposed flow diffusion flame; oxygen index.

An opposed flow diffusion flame technique (Holve and Sawyer, 1974) was used to measure steady state burning rates and extinction velocities for several polymers (with and without added flame retardants) at varying oxygen concentrations in the oxidizing stream. From these results and an analysis based on extinction Damkohler numbers, overall gas phase activation energies and effective mass transfer numbers were derived. Preliminary findings for flame retardant PMMA show that while flame stability is reduced, (i.e., it takes a higher oxygen concentration to sustain combustion) the burning rate increases. In another case for particle board, boric acid flame retardant is found to reduce the burning rate, but not to have any substantial effect on flame stability. These results suggest that both types of retardants are necessary for effective flammability reduction.

NBS-GCR-75-42. **Technological innovation for civilian, social purposes,** E. R. Mottur, 574 pages (July 1971). Order from NTIS as COM 75-10805.

Key words: civilian, technological innovation; social purposes, civilian; technological innovation.

This book presents the results of the Technological Innovation Policy Project which has been carried out in the Program of Policy Studies of George Washington University, under National Bureau of Standards contracts CST-395 and CST-463. The principal sponsors of the research have been the Office of Invention and Innovation, National Bureau of Standards and the U.S. Arms Control and Disarmament Agency. Supplemental research support has been provided by the National Aeronautics and Space Administration, under NASA Institutional Grant NGR 09-010-030 to the Program of Policy Studies in Science and Technology.

NBS-GCR-75-43. **Feasibility study for a diesel engine condition monitoring system for 1179 class LSTs,** M. B. Peterson, 102 pages (Aug. 1975). Order from NTIS as AD-16782.

Key words: diagnostic systems; diesel engines; maintenance costs; monitoring systems.

A study of the maintenance costs and practices on the LST 1179 class ship has been made to determine if a propulsion diagnostic system would result in cost savings to the Navy or other advantages. In the course of this study, a determination of the current propulsion system malfunctions was made and a listing prepared of the necessary sensor measures to detect these malfunctions. Based upon this information, a diagnostic system was proposed and costed. For the LST 1179 ships a simple data system, which measures the trend analysis parameters (plus critical malfunctions), was found to be cost effective.

NBS-GCR-75-44. **Computer/communications networks on a communitywide basis,** E. F. Clark, S. B. Harvey, C. B. Robbins, R. S. Tall, S. S. Tyler, and G. R. Weinberg, 215 pages (June 1975). Order from NTIS as COM 75-10991.

Key words: broadband interactive terminals; cable television uses; checkless society; computer/communications networks; computer/communications services; computer/communications standards; interactive cable television; nonentertainment television; two-way television; wired city; wired nation.

The purpose of this study is to project the possible impact of computer/communications networks on a communitywide basis and to make recommendations for action required by government and/or industry in order to take advantage of such networks and, hopefully, avoid some of the problems inherent in their development. This report reviews, in general, the issues involved with the future development of cable television as one possible means of "wiring" the community. This report does not attempt to offer detailed solutions to, or discussions of, specific technical, economic, regulatory, legal, or social problems which may be isolated. The report contains a description of two-way cable services, results of a selected opinion survey, the technical and regulatory status of cable television, an outline of network technology, two future contrasting scenarios, a financial model, and conclusions, recommendations, and standards needed. There is a bibliography of 60 sources. The report was prepared under NBS Contract No. 3-36006.

NBS-GCR-75-45. **Pilot investigations into the effect of glare on psychomotor performance,** R. J. Senter, 13 pages (July 1975). Order from NTIS as PB257835.

Key words: glare; lighting; perceptual/motor; psychomotor; safety.

Empirical investigations measured the effects of glare on human psychomotor performance as assessed by a rotary pursuit apparatus. Experiment I demonstrated a minimal performance decrement when glare was reflected off the surface of the pursuit rotor into the subjects' eyes. Following an initial "startle" response, subjects' performance was observed to recover rapidly and at times improve. In Experiment II, then, the glare source was redirected to produce more intense and less diffuse visual interference. Subjects experienced one of two glare levels on three different occasions. A control group was also employed. Again, the major deleterious effect on human performance was a "startle" response produced after intitial exposure to high glare levels. Recommendations were made for future research involving a more complex psychomotor task.

NBS-GCR-75-46. **Methodology for the effective test case selection, Part 1,** W. Howden and L. G. Stucki, 171 pages (Jan. 1974). Order from NTIS as PB247235.

Key words: automatic testing; computer program testing; FORTRAN programs; program analysis; software verification.

The intent of this project was to develop a methodology for partitioning the input domain of a program into equivalence classes. Two sets of input values are to be contained in the same equivalence class if and only if they cause execution of the same path (perhaps to within the number of loop iterations) through a program. The equivalence classes define, therefore, sets of input values which are treated "the same way" by the program. This mapping of input data classes into program execution paths yields a functional description of the program and provides a basis for a systematic approach to test case selection. The investigation began by analyzing the structure of a program and by considering conditions under which certain logical paths are taken. The loop was selected as one of the more complicated structures which had to be investigated. In order to handle loops a boundary-interior methodology was developed. A four phase approach to the general partitioning problem evolved from this methodology. The first phase defines the implicit path description of the partition elements. These descriptions are then simplified in the second phase. The third phase transforms the implicit path descriptions into partially explicit descriptions. The fourth phase consists of predicate solution routines. This boundary interior methodology currently works with simple loops only. Some complex loop structures or improperly nested loops are excluded.

At this point in time, the research efforts documented in this study describe an approach which will achieve the original objective of selecting test data in programs subject to some constraints.

NBS-GCR-75-47. **Methodology for the effective test selection, Phase II, Volumes I and II,** W. Howden and L. G. Stucki, 381 pages (Apr. 1975). Order from NTIS as PB247236.

Key words: automatic testing; computer program testing; FORTRAN programs; program analysis; software verification.

The intent of the Effective Test Case Selection Project is to explore and develop methodologies for partitioning the input space of a program into representative subsets. This ongoing research effort addresses in detail one important aspect of the Automated Verification System Concept being developed at McDonnell Douglas. The problem of providing automated assistance in the selection and construction of meaningful test cases is explored in this study. One key issue of concern involves the identification of a set of criteria for grouping together "similar" program paths. We are faced with the problem of forcing ourselves to find a means of cutting down the number of paths through a program which are significant for testing. Structured programming assists us in the better organization of our programs but yet we still find that exhaustive testing of even structured programs is rarely feasible.

Investigation in the area of automatic selection and construction of test cases has led to the design of a general methodology addressing this problem. The goal of Phase II of this research was to design and implement a prototype system in order to assess its utility and come to a better understanding of the basic program testing problems. The approach taken was general and can be applied to programs in different languages although it was designed with FORTRAN programs in mind.

The prototype system breaks a program down into a finite number of standard sets of program paths. It then attempts to simplify and display the relevant statements and predicates for each class to be tested.

NBS-GCR-75-48. **The avoidance of progressive collapse: Regulatory approaches to the problem,** E. F. P. Burnett, 180 pages (Oct. 1975). Order from NTIS as PB248781.

Key words: abnormal loading; building regulations; design process; European; progressive collapse; regulatory process.

The progressive-collapse related provisions of the building regulations of the United Kingdom, Sweden, Denmark, West Germany, Netherlands, Canada, France, and Eastern Europe are studied in detail. The various regulations are discussed individually for their content, background and interpretation. The report is concluded with a discussion of both building regulatory and design problems associated with the implementation of progressive collapse design requirements. A comparative evaluation is then made of the regulations discussed in the report.

NBS-GCR-75-50. **A theoretical analysis of the ASTM E-119 standard fire test of building construction and materials,** A. M. Kanury and D. J. Holve, 141 pages (Aug. 1975). Order from NTIS as PB247939.

Key words: ASTM Standard E119; building construction; charring; combustion; fire endurance; fire test; flame emissivity; heat transfer; pyrolysis; radiant heat; thermal inertia.

This report describes a theoretical analysis of the ASTM E-119 Standard Fire Test. Both analytical and numerical analyses of the test are performed, indicating how various physical, chemical, and structural variables influence the fire endurance of a construction

member. Walls, door, floors and ceilings in heavy timber construction are considered, represented mathematically as "slabs." Wood, gypsum board, and composite wood-gypsum board "slabs" are discussed. The effects of various fire exposure conditions on the endurance time are assessed. Radiant heat transfer is the dominant heat transfer mode and reradiation properties of the exposed material have a strong influence on the fire endurance time. Thus, the true measure of fire severity is given by the heat flux to the specimen, a function of both the furnace temperature and emissivity.

The exact temporal distribution of temperature exposure has little effect on the fire endurance time as compared to the standard ASTM temperature-time curve. Future improvements of the ASTM E-119 test should focus more on the control, measurement, and specification of the heat flux exposure condition rather than the furnace temperature history.

NBS-GCR-75-51. **Detector sensitivity and siting requirements for dwellings,** R. W. Bukowski, T. E. Waterman, and W. J. Christian, 337 pages (1975). Order from NTIS as PB247483.

Key words: detector sensitivity; detector siting; heat detectors; ionization smoke detectors; photoelectric smoke detectors; residential fires; smoke detectors; tenability levels.

A test program was undertaken to investigate the operation of residential smoke detectors under actual field conditions. The main objectives were to determine: 1) minimum sensitivity, 2) best location and 3) escape time provided by a group of typical detectors. Instrumentation was used to determine theoretical response times of an "ideal" detector as a base line for evaluation of detector performance. The tests were conducted using smouldering or flaming ignition of sofas, chairs and mattresses in various rooms in two abandoned, single-family houses scheduled for demolition. Work was carried out during winter and summer seasons with central heating and cooling on and off.

In addition to a description of the tests and discussion of the results, the report contains all raw data for further analysis by the reader.

The tests indicate both photoelectric and ionization detectors at a sensitivity of approximately 1 percent per foot provide adequate escape time from all the test fires when installed using the following guidelines: 1. The detectors should be installed at the head of each stairway; 2. Outside each separate sleeping area; 3. At least one detector on every level of a multi-level home.

NBS-GCR-76-54. **Characterization of the Stanford Research Institute large-scale heat-release-rate calorimeter,** S. B. Martin, 81 pages (Oct. 1975). Order from NTIS as PB251682.

Key words: calorimeter; combustion; fire test; heat release; limiting thermal index; pyrolysis; radiant heat; thermal sensitivity index.

A scaled up version of the NBS heat release rate calorimeter was constructed at SRI. It can measure specimen sizes up to 18×24 inches over an incident radiant flux range of 1.5 to 7.0 W/cm^2. The performance of the instrument is evaluated and various calibration procedures are described. The effect of specimen size and irradiance is investigated and data is compared with that taken in the NBS instrument. The use of the heat release rate calorimeter as a research tool is discussed. In particular a "limiting thermal index" and a "thermal sensitivity index" are defined.

NBS-GCR-76-55. **Technology for the formulation and expression of specifications. Vol. I: Final report,** J. R. Harris, J. W. Melin, R. L. Tavis, and R. N. Wright, 72 pages (Dec. 1975). Order from NTIS as PB250571.

Key words: building codes; computer model; decision theory; networks; specifications; standards; system engineering.

This report describes a systematic approach to the formulation and expression of specifications that is designed to aid in producing complete, clear, and correct documents. The approach is primarily concerned with the format of specifications, however, it is not possible to entirely separate content and format. It is not expected that the technology will be applied to the formulation of project specifications for construction projects without future study. Three basic tools are used: decision tables for examining the detailed logic contained in each provision, a network for representing the precedence of information in the entire specification, and an outline for organizing all of the provisions in the specification. The report is designed for use by individuals concerned with the preparation of specifications. It does not contain rigorous definitions and proofs of the theorems and algorithms used. Two companion volumes to this report contain a user's manual and a reference manual for the computer software developed as a part of the technology. None of the concepts or algorithms require a computer to be understood or used. Many benefits can be realized by the proper understanding and application of the concepts without using the computer programs.

NBS-GCR-76-56. **Technology for the formulation and expression of specifications. Vol. II: Program user's manual,** J. R. Harris, J. W. Melin, and C. Albarran, 63 pages (Dec. 1975). Order from NTIS as PB250572.

Key words: building codes; computer program; decision theory; networks; specifications; standards; systems engineering.

This report describes the use of three computer programs (DECISION TABLE, NETWORK, and OUTLINE) produced as a part of the study, "Technology for the Formulation and Expression of Specifications." The programs are designed for interactive use from a remote console, and the communication with the programs is in free format, making the programs easy to use for those with limited experience in working computers. The programs are operational on the Burroughs B6700 computer at the Civil Engineering Systems Laboratory (CESL) at the Department of Civil Engineering, University of Illinois, Urbana, Illinois. The principles on which the programs are based and examples of the application of these principles are contained in volume I of this report while a more technical description of the three programs, including logic diagrams, data structure, and program listings, is contained in volume III. This volume contains a description of the use of each program preceded by a chapter describing access to and use of the computer facility at which the programs are operational.

NBS-GCR-76-57. **Technology for the formulation and expression of specifications. Vol. III: Technical reference manual,** R. N. Wright, J. R. Harris, J. W. Melin, and C. Albarran, 118 pages (Dec. 1975). Order from NTIS as PB250573.

Key words: building codes; computer program; decision theory; FORTRAN; logic design; networks; specifications; standards; systems engineering.

This report describes the three computer programs produced as a part of the study, "Technology for the Formulation and Expression of Specifications." The programs are written in FORTRAN IV and are operational on the Burroughs B6700 computer at the Civil Engineering Systems Laboratory (CESL), Department of Civil Engineering, University of Illinois, Urbana, Illinois. Transfer of these programs to other computing facilities will be aided by the contents of the manual, because the programs are not entirely machine independent. The programs make use of the characteristic word size of the Burroughs equipment (6 characters). Transfer to IBM equipment (which uses 4 characters) will require some reprogramming of the input and output routines. The programs are designed for interactive use from a remote terminal. The input is entered in free format and interpreted by a package of scanning routines at CESL known as PARSE. A manual for PARSE will soon be available from CESL. These pro-

grams are envisioned to be prototypes for a more refined computer aid for use with the technology described in volume I of this report.

NBS-GCR-76-58. **Residential sprinkler-protection study,** H. C. Kung, 126 pages (Nov. 1975). Order from NTIS as PB256291.

Key words: automatic sprinklers; bedroom fires; droplet size; heat absorption; pool fires; residential sprinkler protection; sprinkler operation.

A research program was initiated to study sprinkler control of residential fires. Hexane pool fires were selected to simulate source fires. The key parameters of investigation were water-discharge rate and drop size. Results show that as the median drop size decreases at constant discharge rate, an increased reduction is observed in: 1) heat-release rate of the fire, 2) convective heat flux through the room opening, 3) ceiling temperature, 4) gas temperature inside the room, and 5) outflow gas temperature. A correlation has been established between heat-absorption rate and the relative median drop size of the spray. The ratio of the heat-absorption rate to the heat release rate, normalized with the water discharge rate, varies as the minus-0.68 power of the relative median drop size.

A realistic bedroom fire test with flaming ignition was also conducted to evaluate the optimum water discharge rate and sprinkler-orifice diameter determined in the pool-fire tests. The result demonstrated that the suggested optimum sprinkler discharge rate is capable of controlling a realistic bedroom fire.

NBS-GCR-76-59. **Sound power measurements in reverberation chambers,** J. Tichy, M. Brien, and K. Roy, 233 pages (Jan. 1976). Order from NTIS as PB256639.

Key words: measurement technology; reverberation rooms; sound measurement; sound power; sound power levels.

Determination of the sound power emitted by small sources using reverberation rooms is becoming increasingly important as society seeks to implement noise control measures. Many of the critical measurement processes are indicated in American National Standard S1.21-1972, "Methods for the Determination of Sound Power Levels of Small Sources in Reverberation Rooms." This standard, as now embodied, represents a major advance in the state-of-the-art of reverberation room measurement of sound power. It incorporates the best currently available interpretation of measurement technology which is the subject of ongoing research.

NBS-GCR-76-60. **Fire fighter mortality report,** T. Balanoff, 170 pages (Mar. 1976). Order from NTIS as PB253588.

Key words: fatalities; fire fighter; occupational safety and health.

This 15-month study involved the investigation of 101 fire fighters in-the-line of duty deaths. The breakdown of cause of death was: 45 heart attacks, 13 building collapse, 12 burns, 9 smoke inhalations, 6 apparatus accidents, 5 electrocutions, and 1 equipment failure. There tended to be a higher incidence of fatalities occurring in the Mid-Atlantic, East, and New England areas. The mean age of fire fighter's fatality was 43.5 and the mean years of service was 15.8. Sixty percent of the fatalities occurred to men holding the rank of fire fighter. The vast majority of fire fighters who died in the line of duty worked either a split shift (10/14) or a 24-hour shift. There were 14 volunteer fire fighter fatalities.

Summaries of every case are provided in one of three sections: *Fire Fighters Killed While Fighting Fires, Fire Fighters Killed in Non-Fire Situations,* and *Fire Fighters Killed by Heart Attack.*

NBS-GCR-76-61. **Method to determine quality of sapphire,** M. T. Duffy, P. J. Zanzucchi, and G. W. Cullen, 88 pages (Sept. 1975). Order from NTIS as PB253553.

Key words: differential reflection; epitaxial semiconductor devices; Kramers-Kronig relation; multiple reflection; sapphire surfaces; silicon films; specular reflection.

Infrared optical techniques including specular reflection, multiple reflection and differential reflection measurements have been used to evaluate the quality of sapphire surfaces used in epitaxial semiconductor devices. The specular reflection data have been analyzed by use of the Kramers-Kronig relations. These data give a basis for interpreting multiple reflection measurements which are being evaluated for both research and production quality control of sapphire substrates. Correlation of optical reflectance data to x-ray, electrical (e.g., Hall measurements), optical microscopy, and chemical (etch) data is in progress to establish the validity of inferring the extent of lattice damage from reflectance measurements. Application of optical techniques to the characterization of sapphire surfaces, and to semiconductor and dielectric materials in general, is considered. In this context, the optical properties of epitaxial silicon films (on sapphire) have been investigated and, where possible, correlated with the electrical properties of the films as well as with the surface condition of the starting substrates.

NBS-GCR-76-63. **Disk drive interface characteristics,** 105 pages (Apr. 9, 1976). Order from NTIS as PB256440.

Key words: computer disk controllers; computer disk drives; computer disk interface; disk controllers; disk drive characteristics; disk pack interchangeability; disk track format; interface electrical characteristics; interface functional characteristics; removable disk packs.

This report describes and compares the various characteristics of the interface between computer disk drives and disk controllers for those drives using removable disk packs having a storage capacity of approximately 100 million bytes or greater. It presents the findings of an investigation conducted for the National Bureau of Standards in support of the possible development of a Federal Information Processing Standard. Disk pack interchangeability, drive performance characteristics, interface functional characteristics, and interface electrical characteristics are described. The conclusion is reached that although nearly all of the drives reviewed use the same type of disk pack, at the circuit and electrical level substantial differences of a detailed engineering nature exist in the interfaces. Two appendices are given describing (A) details of track format (IBM-compatible) and (B) drive cable attachments and pin numbers. Thirty-three tables and five figures are given. This report was prepared under NBS Contract No. 5-35924.

NBS-GCR-76-64. **Automated integrated circuit processing and assembly,** H. G. Rudenberg, 84 pages (Apr. 1975). Order from NTIS as PB255445.

Key words: automation; electronics; integrated circuits; measurement technology; semiconductor devices; semiconductor process control; silicon.

This report describes the results of a study on automated procedures for integrated circuit (IC) processing and assembly by the semiconductor industry. Emphasis is on automated IC production, especially processing of wafers and assembly of chips into devices. Major operations that are already or may be automated are identified, and future directions are recommended. Information has been derived primarily from interviews in industry and analysis of automated production equipment. The report discusses the susceptibility of processes to automation: a major requirement for automation is that measurement and control techniques be available to provide consistent results from the processes chosen. The automation status of the key process steps is outlined, and the expected evolution to complete computer control is characterized. Measurement techniques reported are directed towards categories suitable for automation of production in respect to accuracy, range and type. The report cites economic and technical factors likely to inhibit automation

in the future, and some factors favoring its adoption. A number of priorities for further action are presented. Differences between the criteria used in automating commercial IC production and automating fabrication of devices for DOD electronic systems are described. Additional information includes references listed in the last section of the report; and summaries of the companies contacted or making equipment analyzed, and of important problems in IC processing or automation perceived by respondents are presented in appendices.

NBS-GCR-76-69. **Methodology for the effective test case selection, Phase III. Final report,** W. Howden and L. G. Stucki, 123 pages (Mar. 1976). Order from NTIS as PB254276.

Key words: automatic testing; computer program testing; FORTRAN programs; program analysis; software correctness; software verification; symbolic program evaluation.

The intent of the Effective Test Case Selection Project is to explore and develop methodologies for improving the tasks of computer program analysis and testing. This research effort explores in detail the problem of providing automated assistance in the selection and construction of meaningful test cases for computer applications programs. Key issues involve the identification of criteria for grouping together "similar" program paths, and a means of reducing the number of paths through a program which needs to be analyzed to ensure correctness. The investigation has led to design of a general methodology addressing this problem. Phase III of this research has resulted in the completion of a prototype software testing tool called DISSECT. The DISSECT system addresses the general methodology as well as the design and implementation of additional features whose importance was indicated by experiments with an initial Phase II system. DISSECT provides capabilities to analyze FORTRAN program paths and to symbolically evaluate the potential execution results. Commands are available to select program paths based upon branches and number of loop iterations, and to select DISSECT outputs such as path descriptions or the set of input predicates that cause paths to be followed. DISSECT is an experimental program, written in LISP for a Digital Equipment Corporation PDP-10 computer.

NBS-GCR-76-70. **An investigation of test methods for determining the flammability hazards of fabrics,** K. N. Yeh, I. Block, B. F. Smith, and S. Spivak, 67 pages (June 21, 1976). Order from NTIS as PB254748.

Key words: fabric flammability; fabrics; ignition; heat energy; tests.

The measurement of char length and burn time of a variety of sample specimens was conducted to determine the effects of varying sample size, sample shape, ignition source and air flow past the sample, on these two parameters.

In addition, samples tested in the DOC FF3-71 cabinet were subjected to conditioning at various relative humidities prior to evaluation.

The results of this work indicate that flammability test methods should conform to the following guidelines: (1) the suspension method should be such as to exert as little force in the plane of the fabric as possible, (2) the test specimen should be wide enough to permit unlimited burning in all directions, (3) the ignition source should be capable of providing a precise energy input at a constant rate to the fabric, (4) a forced air flow through the cabinet may be required, (5) although preconditioning humidity may not greatly affect the results when testing nonhydrophilic thermoplastics, moisture sorption can be important, and (6) seamed samples are unnecessary except where the added thread is a significant portion of the weight of the fabric under test.

NBS-GCR-76-71. **Extinguishment in apparel textiles,** G. Tesoro and S. Backer, 60 pages (Oct. 1975). Order from NTIS as PB254751.

Key words: cotton; cotton/polyester; extinguishment; fabric flammability; fabrics; fibers; finishes; flame retardant treatments; nylon; wool.

An experimental investigation of the extinguishability during combustion of various apparel fabrics was conducted. Cotton, wool, nylon, cotton/polyester and FR cotton/polyester were ranked according to burning behavior under test conditions of DOC-FF-3-71 with the addition of heat sinks near the fabric. Stationary and movable heat sinks of various thermophysical properties, geometries, dimensions and speeds were considered.

It was found that extinguishability is affected by fiber type and finish, by weight per unit area and structure. Two parameters were identified to measure relative extinguishability: (1) minimum constant spacing (between fabric and heat sink) needed to induce extinguishment, and (2) the maximum char length obtained after extinguishment in the case of a variable fabric to heat sink spacing. It is concluded that relative differences in ease of extinguishment of nonthermoplastic fabrics can be quantitatively and reproducibly measured.

NBS-GCR-76-72. **Evaluation of fire protection spray devices: The state-of-the-art,** W. G. Labes, 102 pages (June 30, 1976). Order from NTIS as PB256190.

Key words: automatic sprinklers; bibliography; droplet size; fire suppression; spray nozzles; spray patterns; test methods; water distribution; water spray.

This report represents a descriptive review of the state-of-the-art on spray nozzle characteristics, drop-size measurement, and drop-size distribution and spray pattern analysis. A discussion of significant information gaps is also included. A list of references supporting these findings has been prepared and appears as an appendix to this report.

It is concluded that the evaluation of fire protection spray devices must be updated to include considerably more than the volume distribution of water at some standardized distance below the deflector of a sprinkler. Since both the fire environment and the spray structure are three dimensional by nature, and, as these opposing forces occur simultaneously in real fire situations, it is desirable to understand in greater detail the application of water to fire by fire protection spray devices.

NBS-GCR-76-73. **Mapping of recurrent behavior patterns in institutional building under fire: Ten case studies of nursing facilities,** L. Lerup, D. Greenwood, and J. S. Burke, 165 pages (July 1976). Order from NTIS as PB257424.

Key words: building fires; case studies; critical events; decisions; episodes; fires; home for the aged; hospital fires; human behavior; institutions; mapping; models; nursing homes; realms.

Report provides a graphical and narrative mapping of the fire and people behavior patterns in 10 institutional buildings under fire conditions. The case studies concentrate on nursing home type facilities. The report maps out the progress of the fire by realms of fire development and critical events separating these realms. A parallel mapping is included for human behavior covering the episodes and decisions involved. A conceptual framework and analysis of the basic concepts and approaches are included.

NBS-GCR-76-74. **Low-rise low-cost housing and extreme wind related problems in Bangladesh,** J. R. Choudhury, 39 pages (Apr. 1975). Order from NTIS as PB256771.

Key words: Bangladesh; housing; low-cost housing; low-rise buildings; wind.

This report furnishes information on socioeconomic factors, the present conditions of urban and rural housing, and housing needs in

Bangladesh for the next 10 years. It also provides data on available wind speed records and wind damage statistics and discusses some special problems unique to Bangladesh.

NBS-GCR-76-75. **Accident research methodologies,** N. W. Heimstra, 27 pages (Dec. 10, 1976). Order from NTIS as PB261201.

Key words: accident research; countermeasures; epidimiology; laboratory research; methodology; naturalistic studies; safety.

This overview paper discusses some of the problems encountered and methodologies used in accident research. Several methodologies are briefly presented—the epidimiological approach, laboratory studies, case studies, and naturalistic observations. Special problems in childhood accident research and in countermeasures are emphasized and a model of human accident behavior is presented. Selected references are included.

NBS-GCR-76-76. **Home accidents and safety,** M. Werber, 100 pages (Dec. 10, 1976). Order from NTIS as PB261200.

Key words: accidents; accident research; consumer accidents; epidimiology hazards; home safety; methodology; safety.

This report briefly summarizes published research in home accidents and safety. Areas covered are: theoretical approaches to safety, behavorial interpretations, research design, hazardous products and conditions, childhood and old age accidents, epidimiology and public health, and accident prevention. In addition to the reference and general bibliographies, an author index, a subject index and permuted title index are included.

NBS-GCR-76-79. **A problem in fire safety: Flame spreading across liquid fuels,** F. L. Dryer, I. Glassman, and W. A. Sirignano, 30 pages (Sept. 15, 1976). Order from NTIS as PB259127.

Key words: combustion models; flame spread; fluid flow; laser doppler velocimetry; liquid fuels; solid fuels; surface tension.

This report provides a brief summary of experimental and theoretical work carried out at Princeton University on flame spreading across liquid fuels. The importance of surface tension driven flows ahead of the flame front in controlling flame spread across liquids at temperatures below the flash point was demonstrated experimentally. Buoyancy and radiation effects were also present but were of lesser importance. Variations in the temperature of the liquid surface are attributed to eddies in the gas phase ahead of the flame front. These eddies may also play a role in flame propagation across solid combustibles. It is proposed to investigate these eddies by means of laser doppler velocimetry. A two-dimensional, steady-state computer program is under development for use as a tool in studying flame propagation above liquid and solid fuels.

NBS-GCR-ETIP 73-01. **Study of strategies for market aggregation,** J. D. Lewis and H. S. Kleiman, 253 pages (May 11, 1973). Order from NTIS as COM 73-11373.

Key words: aggregation, market; market aggregation; tool, market.

This report considers the opportunities for stimulating the development and application of technology in the civilian sector through the use of the tool of market aggregation. Market aggregation is defined as a restructuring of demand to reduce variability in the marketplace. Such reduced variability might be manifest in an increased concentration of the purchasing activities of different buyers or in new standards for products or for their use. In addition to discussions of background and methodology, the report develops a conceptual framework for market aggregation that provides a specific aggregation strategy to treat a given problem. Next four case studies are presented to provide insights for the conceptual framework. These are followed by a discussion of major factors to be considered when contemplating or using market aggregation. The report concludes with suggestions on possible experiments with the market aggregation tool. One appendix to the report discusses antitrust considerations in market aggregation and another provides full details on the four case studies.

NBS-GCR-ETIP 73-02. **Government procurement as an incentive to commercial technology and innovation,** 159 pages (Mar. 1973). Order from NTIS as COM 73-11375.

Key words: ETIP; government procurement; performance specifications; procurement mechanisms; technology incentives.

The Federal Government influences the development and application of technology through its procurement of R&D to meet federal needs, its purchase of goods and services for federal use, and its subsidization of purchases made by other bodies. By altering certain aspects of its procurement practices and procedures, which are described and discussed in this study, the government may further stimulate private investment in technological innovation. Some suggested procurement approaches can be implemented within the confines of existing legislation and without major regulatory change. These include incentives (patent and financial) to commercialize the results of government R&D, the increased use of performance specifications in the procurement of commercial goods and services, and a government-wide policy to procure innovative goods and services that impact favorably on particular national needs. The procurement approaches can be tested by experiments of the one-time "demonstration" type or of the more practical "piggy-back" type, in which a planned or ongoing procurement is modified so as to stimulate innovation. Several examples of experiments that meet appropriate criteria are given in the report, and recommendations for selecting, designing, performing, and evaluating additional experiments are presented.

NBS-GCR-ETIP 73-03. **Technology transfer and technological innovation: Annotated and selected bibliographies,** 107 pages (July 10, 1973). Order from NTIS as COM 73-11374.

Key words: bibliography, technological innovation; innovation, technological; technological innovation.

The works included in the bibliographies have been categorized according to their relevance to federal and nonfederal activities as well as to the general quality and significance of their discussions on technology transfer or technological innovation. The annotated bibliography includes 315 entries relevant to federal government action and all are of high quality. Approximately 50 additional entries for work of high quality with relevance to nonfederal action are also included. The selected bibliography contains approximately 375 entries, categorized in the same manner.

NBS-GCR-ETIP 73-04. **Experimental technology incentives program procurement experiment plan I: Stimulating noise control technology in consumer products through federal government procurement action,** 18 pages (Oct. 1973). Order from NTIS as COM 74-10256.

Key words: ETIP; government procurement policy; noise reduction; performance specification; technology incentives.

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards (NBS) is part of the continuing effort to understand how the federal government can work more effectively with industrial partners from the private sector in the application of science and technology in the nations interest. ETIP has selected the Federal government procurement policy as one of the specific areas in which to focus its investigations. This experimental plan details the particulars of one of a series of experiments to be conducted by ETIP in association with the Federal Supply Services of the General Services Administration. The specific objective of this experiment is to

seek the introduction of improved noise control technology into power lawn mowers that are used by both the government and consumers generally. A 2-step fixed-price negotiated procurement experiment will be conducted utilizing a new performance specification relative to noise emission of the lawn mowers.

NBS-GCR-ETIP 73-05. **Experimental technology incentives program procurement experiment plan 2: Stimulating efficiency and noise abatement in room air conditioners through federal government procurement action,** 51 pages (Nov. 1973). Order from NTIS as COM 74-10257.

Key words: energy conservation; ETIP; government procurement policy; noise reduction; performance specification; technology incentives.

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards (NBS) is part of the continuing effort to understand how the federal government can work more effectively with science and technology in the nations interest. ETIP has selected the federal government procurement policy as one of the specific areas in which to focus its investigations. This experimental plan details the particulars of one of a series of experiments to be conducted by ETIP in association with the Federal Supply Services of the General Services Administration. The specific objective of this experiment is to seek the introduction of improved noise control technology and improved energy technology into room air conditioners that are used by the government and by consumers. The procurement approach to be tested will be the approach of performance factors in evaluation of bids responding to a formally advertised procurement.

NBS-GCR-ETIP 73-06. **Experimental technology incentives program procurement experiment plan 3: Stimulating increased efficiency in frostless household refrigerators through federal government procurement action,** 45 pages (Nov. 1973). Order from NTIS as COM 74-10258.

Key words: energy conservation; ETIP; government procurement policy; technology incentives.

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards (NBS) is part of the continuing effort to understand how the federal government can work more effectively with industrial partners from the private sector in the application of science and technology in the nations interest. ETIP has selected the federal government procurement policy as one of the specific areas in which to focus its investigations. This experimental plan details the particulars of one of a series of experiments to be conducted by ETIP in association with the Federal Supply Service of the General Services Administration. The specific objective of this experiment is to see improved energy technology in production of frostless household refrigerators to be used by government and by consumers. The procurement approach to be tested will be the use of life cycle cost comparison bid evaluation in a formally advertised procurement.

NBS-GCR-ETIP 73-07, Vol. 1. **Development of criteria and an operating procedure for screening government owned patents,** P. G. Dickey, K. D. Brown, R. W. Aaron, and S. A. Lambert, 82 pages (Apr. 30, 1973). Order from NTIS as COM 74-10939.

Key words: ETIP; government-owned patents; patent screening; technology incentives.

This two volume report describes the development of procedures to screen government-owned patents for commercial potential, based on the patent screening practices of a selected sample of industrial firms; results of the research show that the operating procedure developed satisfies the basic requirements of the study. Technology Generalists were about to apply the developed procedure with a minimum of assistance from Technology Specialists. The procedure, however, cannot readily be applied by nonexperts. Test results of screening selected patents were consistent and in accordance with expected results. The conclusion is drawn that the results indicate that the developed operating procedure replicates the approaches both formal and intuitive commonly used by industrial executives and experts to screen patents. The benefits and usefulness of operating procedures are summarized as follows: 1. Systematization of a screening process which heretofore was essentially random; 2. Uniform application of eight criteria consistently regarded as most important by industrial executives in patent screening; 3. A means for prioritizing patents in terms of some quantitative measurement of commercial potential; 4. A means of screening large numbers of patents in an efficient manner; 5. Procedure can be utilized by generalists as well as specialists.

NBS-GCR-ETIP 73-07, Vol. 2 **Development of criteria and an operating procedure for screening government owned patents,** P. G. Dickey, K. D. Brown, R. W. Aaron, and S. A. Lambert, 316 pages (Apr. 30, 1973). Order from NTIS as COM 74-10940.

Key words: ETIP; government-owned patents; patent screening; technology incentives.

This two volume report describes the development of procedures to screen government-owned patents for commercial potential, based on the patent screening practices of a selected sample of industrial firms; results of the research show that the operating procedure developed satisfies the basic requirements of the study. Technology Generalists were about to apply the developed procedure with a minimum of assistance from Technology Specialists. The procedure, however, cannot readily be applied by nonexperts. Test results of screening selected patents were consistent and in accordance with expected results. The conclusion is drawn that the results indicate that the developed operating procedure replicates the approaches both formal and intuitive commonly used by industrial executives and experts to screen patents. The benefits and usefulness of operating procedures are summarized as follows: 1. Systematization of a screening process which heretofore was essentially random; 2. Uniform application of eight criteria consistently regarded as most important by industrial executives in patent screening; 3. A means for prioritizing patents in terms of some quantitative measurement of commercial potential; 4. A means of screening large numbers of patents in an efficient manner; 5. Procedure can be utilized by generalists as well as specialists.

NBS-GCR-ETIP 75-01. **Fiber, textile and apparel research—Cotton polyester blends, July 1974-75,** 143 pages (Aug. 1975). Order from NTIS as COM 75-11369.

Key words: cotton polyester blends; ETIP; flame retardants; flammability; R&D contracting; radiation grafting; research consortia.

As a part of its experimental program with respect to the funding of civilian research and development by the Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract where the basis for award was rather unique. The two major criteria for the award were: (1) the identification of specific research to be pursued in a general problem area and (2) the efforts at commercialization that the contractor indicated he would pursue. The contract was awarded to a consortium headed by Clemson University. This report covers the technical progress made during the first year of the research activity.

Based on this research, it is now possible to predict with a high degree of certainty, the types of chemical agents which should be effective in rendering cotton and polyester fabrics flame retardant. The interaction which occurs between fiber systems in a blend have been elucidated. Further, it has been possible to determine the effect of various distributions of the flame retardant chemicals among fibers in several systems. Four specific approaches are now under investigation.

NBS-GCR-ETIP 76-03. **Federal funding of civilian research and development, Vol. 1. Summary,** 62 pages (Feb. 1976). Order from NTIS as PB251266.

Key words: decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; policies; private sector; R&D; technological change.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to Arthur D. Little, Inc. to conduct a study whose purpose was "To better understand how federal funding of civilian research and development has functioned as an agent of technological change in the private sector."

The fundamental conclusion reached in the study was "Federally-funded civilian research and development is not sufficient to bring about technological change in the private sector to any significant extent." This is true because R&D cost is a small part of the total cost of bringing technological innovation into the marketplace. The study finds that this fact is often overlooked by federal policy makers in both the Executive and Legislative Branches. It is cited as one of the reasons why many United States companies with proven records of developing and marketing new products often shun federal R&D funds, and why so many federal R&D projects are shelved.

The authors suggest that the results of the study indicate that federal funding of civilian R&D should be formulated in the larger context of the complex process of technological innovation. This volume provides a summary of the study.

NBS-GCR-ETIP 76-04. **Federal funding of civilian research and development, Vol. 2. Case studies,** 335 pages (Feb. 1976). Order from NTIS as PB251683.

Key words: decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; policies; private sector; R&D; technological change.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to Arthur D. Little, Inc. to conduct a study whose purpose was "To better understand how federal funding of civilian research and development has functioned as an agent of technological change in the private sector."

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The authors suggest that the results of the study indicate that federal funding of civilian R&D should be formulated in the larger context of the complex process of technological innovation. This volume provides details of the case studies upon which the findings were based.

NBS-GCR-ETIP 76-05. **Analysis of federally funded demonstration projects, Vol. 1. Executive summary,** W. S. Baer, L. L. Johnson, and E. W. Merrow, 32 pages (1976). Order from NTIS as PB253108.

Key words: demonstration projects; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; technology.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to RAND, Santa Monica, CA, to conduct a study whose purpose was "To develop cost benefit and market/industrial/institutional criteria and guidelines for the use of Federally procured demonstration projects as catalysts for technological change."

The analysis indicated that projects successful in diffusion tend to have the following attributes: (1) A technology well in hand, (2) Cost and risk sharing with local participants, (3) Project initiative from non-Federal sources, (4) The existence of a strong industrial system for commercialization, (5) Inclusion of all elements needed for commercialization, and (6) Absence of tight time constraints.

The study developed guidelines for demonstration projects. These are grouped under the headings of (1) Strategies for Demonstrations, (2) Initial Exploratory Study, (3) Project Planning and Implementation, (4) Management, Monitoring, and Evaluation, and (5) Dissemination of Results. This volume provides an Executive Summary of the research.

NBS-GCR-ETIP 76-06. **Analysis of federally funded demonstration projects, Vol. 2. Final report,** W. S. Baer, L. L. Johnson, and E. W. Merrow, 197 pages (1976). Order from NTIS as PB253918.

Key words: demonstration projects; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; technology.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to RAND, Santa Monica, CA, to conduct a study whose purpose was "To develop cost benefit and market/industrial/institutional criteria and guidelines for the use of Federally procured demonstration projects as catalysts for technological change."

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NBS-GCR-ETIP 76-08. **An analysis of venture capital market imperfections executive summary,** 46 pages (Feb. 1976). Order from NTIS as PB254078.

Key words: capital market imperfections; federal technology policy; SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital.

The study estimated the total flow of funds to small technology based firms, and the composition of that flow according to financial instruments. The relative roles of various suppliers of funds to these firms were assessed. No evidence was found of substantial market imperfections that restrict the flow of funds to small technology based firms. There was no indication that small technology based firms paid higher rates of interest or returned their unaffiliated stockholders more than other small firms. There was no indication that suppliers of funds to small technology based firms earned high-

profits than could be earned by investing in listed securities. No elements of the structure of behavior in the venture capital industry were found which would enable firms in the business to charge higher rates or earn greater profits than necessary to compensate for the risks assumed.

The conclusion that there are no substantial capital market imperfections does not necessarily imply that the supply of funds to new technology based firms is in some sense ideal. Investment in small technology based firms may generate external effects so that the benefits to society from investment in these firms may not be accurately reflected in the prices those firms can get for their products and services or the rate of return which investors in such firms can expect to earn.

NBS-GCR-ETIP 76-09. **Life cycle costing in the procurement of electric ranges,** 27 pages (1976). Order from NTIS as PB253488.

Key words: electric ranges; energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments.

This report documents life cycle cost procurements of electric ranges made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why electric ranges were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-10. **Life cycle costing in the procurement of refrigerator-freezers,** 40 pages (1976). Order from NTIS as PB253260.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; refrigerators.

This report documents life cycle cost procurements of refrigerators made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why refrigerators were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-11. **An evaluation of the Small Business Administration Innovation Loan Program,** 119 pages (1976). Order from NTIS as PB253115.

Key words: Experimental Technology Incentives Program; federal policies; innovation loans; R&D; small business; Small Business Administration; technological change.

This is an evaluation of the Innovation Loan Program (ILP), developed and administered by the Small Business Administration during 1966-70 to assist small businesses to market innovations they had developed. The agency's objective was to support new products or processes which could be expected to achieve significant societal benefits.

Approximately 90 loans totaling more than $7 million were made during the life of the program. This evaluation was limited to the 37 identifiable loans.

Borrower entities were analyzed to determine patterns of success and failure, and the merits of their innovations. Technological sophistication and social utility of the innovations were assessed. Employment and tax effects of the program were measured. Borrowers were found to be typically small, newly established, undercapitalized firms with a single product. The program was adjudged a qualified success, and revival of this or a similar program is recommended.

NBS-GCR-ETIP 76-12. **An analysis of venture capital market imperfections,** 438 pages (Feb. 1976). Order from NTIS as PB254996.

Key words: capital market imperfections; federal technology policy; SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital.

The study estimated the total flow of funds to small technology based firms, and the composition of that flow according to financial instruments. The relative roles of various suppliers of funds to these firms were assessed. No evidence was found of substantial market imperfections that restrict the flow of funds to small technology based firms. There was no indication that small technology based firms paid higher rates of interest or return their unaffiliated stockholders more than other small firms. There was no indication that suppliers of funds to small technology based firms earned higher profits than could be earned by investing in listed securities. No elements of the structure of behavior in the venture capital industry were found which would enable firms in the business to charge higher rates or earn greater profits than necessary to compensate for the risks assumed.

The conclusion that there are no substantial capital market imperfections does not necessarily imply that the supply of funds to new technology based firms is in some sense ideal. Investment in small technology based firms may generate external effects so that the benefits to society from investment in these firms may not be accurately reflected in the prices those firms can get for their products and services or the rate of return which investors in such firms can expect to earn.

NBS-GCR-ETIP 76-13. **Life cycle costing, procurement case 1, room air conditioners,** 28 pages (July 1975). Order from NTIS as PB253475.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; room air conditioners.

This report documents life cycle cost procurements of room air conditioners made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why room air conditioners were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-14. **Life cycle costing, procurement case 2, water heaters,** 24 pages (July 1975). Order from NTIS as PB253476.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; water heaters.

This report documents life cycle cost procurements of water heaters made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program

instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why room air conditioners were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-15. **Life cycle costing, procurement case 3, gas ranges,** 30 pages (Jan. 1976). Order from NTIS as PB253477.

Key words: energy efficient products; Experimental Technology Incentives Program; gas ranges; life cycle costing; procurement experiments.

This report documents life cycle cost procurements of gas ranges made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why room air conditioners were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-16. **An experiment on accelerating the writing of nuclear standards conducted for the American National Standards Institute,** N. G. Wittenbrock, 237 pages (Sept. 1975). Order from NTIS as PB256129.

Key words: administrative experiment; American National Standards Institute; Experimental Technology Incentives Program; Nuclear Regulatory Commission; standards development; technological change.

This project was an *administrative experiment*, run in cooperation with the NRC and the American National Standards Institute. Its purpose was to determine whether any or all of four changes in the method of developing nuclear standards is a desirable method for accelerating the establishment of responsible standards which are approved by ANSI and adopted by the Nuclear Regulatory Commission. Several changes in the normal way consensus standards are drafted were made to see if their development could be expedited and the information underlying them increased. It tested: (1) the use of a full-time committee chairman (versus a volunteer chairman), (2) the provision of technical editorial services for the preparation of early draft standards, (3) the provision of technical secretarial help to expedite the translation of committee discussion into draft standards, and (4) the convocation of committees for an extended period of time by paying out of pocket costs. It was hypothesized that the changes would substantially reduce the amount of time consumed by coordinating views via the mail, telephone, and through shorter meeting periods.

NBS-GCR-ETIP 76-17. **A guide for applying the concepts of life cycle costing to procurements by state and local governments,** 209 pages (1976). Order from NTIS as PB254233.

Key words: bid evaluation; Experimental Technology Incentives Program (ETIP); innovation; life cycle costing; local government; procurement policy; state government.

This guide has been developed to assist the public purchasing community to more fully understand, and use the elements of life cycle costing in the procurement process.

The guide contains chapters on concept and theory of LCC, use of LCC in equipment purchases, use of warrantees in LCC structuring LCC procurements and selected case studies plus appropriate contract clauses in equipment procurement.

The guide has application at the Federal, State and local levels of procurement activity and for industrial purchasing agents as well.

The guide was developed as part of the Experimental Technology Incentives Program's research in the use of procurement policies in providing incentives to innovation and technological change.

NBS-GCR-ETIP 76-18. **Value incentive program household goods shipping containers,** 40 pages (July 1976). Order from NTIS as PB256642.

Key words: Experimental Technology Incentives Program (ETIP); Federal Supply Service; life cycle costing; procurement policy; specifications; value.

This case study covers the use of the Value Incentive C use by a GSA/FSS contractor to make product improvement suggestions on Household Shipping Containers. The use of this clause allows for contractors who hold FSS contracts to make suggestions to reduce the overall cost of procurement to the government and to share in the savings resulting from their suggestion. Copies of the GSA order, and the clause itself are included in addition to the specific changes proposed for the household containers. As the result of this suggestion the government will save about $7.5 million dollars over 10 years. The contractor's share of the first year's savings exceeds $150,000.

NBS-GCR-ETIP 76-19. **Life cycle costing in the procurement of window air conditioners,** 38 pages (July 1976). Order from NTIS as PB256643.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; window air conditioners.

This report documents life cycle cost procurements of window air conditioners made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material containedin the report explains why refrigerators were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparationof the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-22. **Development of flame retardants for polyester/cotton blends,** R. H. Barker and M. J. Drews, 472 pages (Sept. 1976). Order from NTIS as PB257884.

Key words: antimony oxide; bromine; bromine flame retardants; calorimetry; cotton; cotton/polyester; ETIP; fabric flammability; flame retardant mechanisms; flame retardant monomers; flame retardants; hand modifiers; inherently flame retardant polyester; phosphazenes; phosphorus flame retardants; polyester; precondensates; radiation grafting.

Initial studies were carried out to determine the flame retardant characteristics of the individual polyester and cotton fibers. Since previous studies had dealt primarily with cotton and other cellulosic materials, emphasis was placed on the polyester. Structural and chemical factors affecting flammability were determined and evaluated. The interaction of the fibers was studied in both the presence and absence of flame retardants. Several specific types of phosphorus and bromine-containing materials were evaluated to determine their relative retardant efficiencies. Various methods of fixing flame retardants onto polyester were also studied with particular emphasis placed on radiation grafting techniques. Based on the

results of these studies several series of model flame retardant treatments were prepared and evaluated on 50/50 blend fabrics. The results of these studies were then used as the basis for designing new flame retardant systems having a potential for commercial application. These systems include phosphonium oligomers, a bromine-containing phosphazene and brominated aromatics with a brominated acrylate binder.

NBS-GCR-ETIP 76-23. **Value incentive program computer room air conditioning units,** 35 pages (July 1976). Order from NTIS as PB258991.

Key words: computer air conditioning units; Experimental Technology Incentives Program (ETIP); Federal Supply Service; life cycle costing; procurement policy; specifications; value incentives.

This case study covers the use of the Value Incentive Clause by a GSA/FSS contractor to make product improvement suggestions on Computer Room Air Conditioning Units. The use of this clause allows for contractors who hold FSS contracts to make suggestions to reduce the overall cost of procurement to the government and to share in the savings resulting from their suggestion. Copies of the GSA order, and the clause itself are included in addition to the specific changes proposed for the computer room air conditioning units. As the result of this suggestion the government will save about $394,000 dollars over 10 years. The contractor's share of the first year's savings exceeds $7,000.

NBS-GCR-ETIP 76-24. **A framework for analyzing commodity supply restrictions,** 240 pages (1976). Order from NTIS as PB258093.

Key words: applied microeconomic framework; commodity supply crisis; econometric analysis; economic impacts; efficiency impacts; income distribution effects; policy alternatives.

Study addresses commodity supply crises due to producer country export policies, and considers the issue of resource exhaustion only as it relates to this problem. The primary concern is with *economic* impacts and policies. Crises in commodity supplies may well have political impacts, but detailed treatment of such effects is beyond the scope of the study. Possible political and diplomatic constraints on U.S. policies are considered, but the primary concern is with economic impacts.

Policies differ in their effects on the distribution of income between producers and consumers. Such effects are considered, where appropriate. Concentration is on efficiency impacts, however, and there is no attempt to address effects on the size distribution of income.

The basic analytical approach is that of the applied microeconomist working in a supply and demand framework. This framework allows the use of available qualitative economic, econometric and engineering information. There has been no use of mathematical programming or input-output techniques as it is believed that the techniques employed are, for the purposes of this study, more productive within time and budget constraints.

Patent 3,950,995. **Ambient pressure probe,** R. D. Marshall, (Apr. 20, 1976).

Key words: ambient pressure probe; omnidirectional pressure probe; pressure probe shroud; static pressure; weatherproof pressure probe; wind field pressure measurements.

Ambient or static pressure in a fluid stream is sensed with a hollow circular cylinder placed normal to the fluid stream. A shroud is mounted on the cylinder for adjustment over a ring of ports provided in the cylinder. In this manner, the relationship between the internal pressure in the cylinder and the ambient pressure is controllable. Ideally, the internal and ambient pressures are exactly equal. Further, extension of the cylinder above and below the shroud provides symmetry for positive and negative angles of attack.

Patent 3,958,269. **Color subcarrier frequency comparator,** D. D. Davis, (May 18, 1976).

Key words: color subcarrier; frequency calibration; frequency comparator; frequency measurements; oscillator calibration; phase comparison; television receiver.

Apparatus for measuring the frequency of a reference signal which utilizes the color subcarrier signal of a television receiver as a standard frequency signal. In a first embodiment, the reference signal controls a circuit to develop bursts of a synthesized color subcarrier signal, gated at the horizontal line rate of a color television receiver. The synthesized signal is superimposed on the broadcast television signal and applied to the receiver to produce a modulation bar on the screen. Any frequency/phase difference between synthesized and broadcast color subcarrier signals will cause the modulation bar to move laterally across the screen, and/or cause the sequence of colors within the modulation bar to vary. Movement of the modulation bar is a coarse indication of frequency difference and change of the color sequence within the bar is a precise indication of phase difference.

In a second embodiment, the locally synthesized color subcarrier signal and the color subcarrier signal of the television receiver are compared in a linear phase comparator to develop a signal having an instantaneous voltage proportional to the phase difference between the two signals. The phase signal controls a generator which develops a cursor line on the screen. Movement of the line across the screen provides a coarse indication of phase difference between the subcarrier signals. The phase signal is also applied to a digital counter which affords a precise readout of the phase difference between the signals.

Patent 3,966,413. **Electrochemical chlorine flux monitor,** G. Marinenko, (June 29, 1976).

Key words: calibration cell; chlorine concentration; chlorine monitor; electrochemical calibration; internal calibration; iodine detection; potassium iodide.

This apparatus for monitoring the chlorine concentration of water has a unique internal calibration capability and a high sensitivity. A water sample is mixed with a solution of potassium iodide and the reaction produces a mole of iodine for every mole of chlorine present in the water. The mixture is passed through a detection and calibration assembly wherein the iodine is detected amperometrically by a detection cell. Calibrant (known) iodine fluxes, equivalent in effect to the unknown chlorine-produced iodine fluxes, are supplied to the detection cell during calibration runs by means of an upstream calibration cell which electrolyzes the iodide (preferably added to distilled water) to iodine at flux rates given simply by the electrolyzing currents divided by Faraday's constant. An electronics package having gain and offset controls and a concentration display is provided.

Patent 3,967,140. **Tunnel diode pulse generator,** J. R. Andrews, (June 29, 1976).

Key words: directional coupler; fast risetime; flat pulse baseline/topline; pulse generator; step waveform; tunnel diode.

A tunnel diode pulse generator is triggered through a directional coupler. The tunnel diode is coupled across one end of an output transmission line through an impedance matching network which matches the characteristic impedance of the transmission line. Triggering signals are coupled to the transmission line through the directional coupler for propagation of triggering impulses towards the tunnel diode.

Patent 3,968,363. **Radiation flux averaging device of high efficiency,** K. D. Mielenz, R. Mavrodineanu, and E. D. Cehelnik, (July 6, 1976).

Key words: averaging sphere; averaging ultraviolet and visible light; radiation converter; ultraviolet averaging sphere; ultraviolet to visible converter.

A flux averaging sphere having an improved efficiency and a high averaging and diffusing effectiveness over the visible and ultraviolet ranges. The interior surface of the sphere is coated with a white diffusing material which has a higher reflectance for visible radiation than for ultraviolet radiation. A radiation converting means is disposed inside the sphere for converting incoming ultraviolet radiation to visible radiation before reflections from the sphere wall occur. The radiation converting means is transparent to incoming visible radiation which therefore remains unaffected. The efficiency of the device is further improved by eliminating the small gap between the output area and the face of the photomultiplier tube. The sphere is formed with a tapered tubular extension at the output area and the face of the photomultiplier tube is abutted against the end of the extension thereby forming a substantially light tight seal.

Patent 3,970,862. **Polymeric sensor of vibration and dynamic pressure,** S. Edelman, S. S. Roth, and J. F. Mayo-Wells, (July 20, 1976).

Key words: dynamic pressure transducer; polymeric film transducer; sandwiched polymeric films; vibration transducer.

A transducer, and method for making it, comprising a composite film for sensing pressure comprising a pair of film sandwiches, each sandwich comprising a poled polymeric films with metallic film electrodes on opposite surfaces. One electrode does not extend quite to the end of the polymer and is considered the "hot" electrode. Two such transducer film sandwiches are cemented together with the hot electrodes in contact with each other, the center wire from a coaxial cable being in contact with and between them. The outer electrodes are electrically connected to the shield of the cable and the connection is encapsulated.

Patent 3,973,970. **Additive composition for making dental materials,** C. P. Mabie, (Aug. 10, 1976).

Key words: ammonium stabilized silica and alumina sols; colloidal alumina and silica for dental porcelain; dental porcelain; porcelain balling reduction.

Addition of ammonium stabilized colloidal silica, borax and boric acid to the distilled water in which dental porcelain is fired greatly increases the firing range by reducing "balling" or edge rounding, and flow deformation. Greatly increased machinability and indefinitely prolonged green-biscuit strength is also obtained by the use of the present additive without deleterious effects on the porcelain.

Patent 3,975,940. **Portable tester for measuring the static coefficient of friction between a floor surface or the like and a shoe sole or heel material or the like,** R. J. Brungraber, (Aug. 24, 1976).

Key words: floor slipperiness; slipperiness tester; static coefficient of friction measurement.

A portable testing device for determining the static coefficient of friction between a floor surface and a shoe sole or heel material includes an upper, weighted strut movable within a vertical plane and a lower strut pivotably secured to the bottom portion of the upper strut. The upper strut is mounted within a bearing block which is translatably movable within a horizontal plane, and the lower strut has secured to the bottom portion thereof a yoke within which a metal shoe carrying a representative shoe sole or heel material to be tested is pivotably secured. The yoke and shoe project through the base of the device framework so as to rest upon the flooring material being tested, and a trigger is disposed near the shoe so as to be actuated thereby upon the occurrence of slip between the shoe and flooring materials. The trigger is in turn connected to a friction clutch which controls the movement of a graduated rod, which is coupled to the bearing block so as to monitor the movement thereof and upon which the static coefficient of friction data is indicated, and upon the occurrence of slip, the movement of the rod is arrested by the clutch mechanism whereby the friction coefficient may be read directly from the rod.

Patent 3,996,120. **Laser-induced photochemical enrichment of boron isotopes,** S. M. Freund and J. J. Ritter, (Dec. 7, 1976).

Key words: boron isotope separation; boron trichloride; isotope enrichment; laser isotope separation; photochemical enrichment.

A boron trichloride starting material containing both boron-10 isotopes and boron-11 isotopes is selectively enriched in one or the other of these isotopes by a laser-induced photochemical method involving the reaction of laser-excited boron trichloride with either H_2S or D_2S. The method is carried out by subjecting a low pressure gaseous mixture of boron trichloride starting material and the sulfide to infrared radiation from a carbon dioxide TE laser. The wave length of the radiation is selected so as to selectively excite one or the other of boron-10 BCl_3 molecules or boron-11 BCl_3 molecules, thereby making them preferentially more reactive with the sulfide. The laser-induced reaction produces both a boron-containing solid phase reaction product and a gaseous phase containing mostly unreacted BCl_3 and small amounts of sulfhydroboranes. Pure boron trichloride selectively enriched in one of the isotopes is recovered as the primary product of the method from the gaseous phase by a multi-step recovery procedure. Pure boron trichloride enriched in the other isotope is recovered as a secondary product of the method by the subsequent chlorination of the solid phase reaction product followed by separation of BCl_3 from the mixture of gaseous products resulting from the chlorination.

This column lists all outside publications by the NBS staff, as soon as possible after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

16029. Heydemann, P. L. M., **Ultrasonic measurements at pressures up to 50 kbar,** *Proc. Intern. Colloq. Les Propriétés Physiques des Solides Sous Pression, Grenoble, France, Sept. 8-10, 1969,* No. 188, pp. 461-467 (Centre National de la Recherche Scientifique, Paris, France, 1970).

Key words: bulk modulus; equation of state; high pressure; phase transitions; potassium chloride; ultrasonics.

Ultrasonic measurements as a function of pressure or temperature provide one of the most accurate means to determine pressure or temperature dependence of the bulk modulus and the density of both liquids and solids. Such measurements are currently carried out with very high accuracy at pressures up to about 4 kbar (1 kbar=10^8N/m^2) in several laboratories.

If the material under investigation undergoes transitions at higher pressures, or if the bulk modulus is noticeably nonlinear with pressure, ultrasonic measurements at pressures higher than 4 kbar are needed. This report describes our methods to carry out such measurements at pressures close to 50 kbar, both under hydrostatic and nonhydrostatic conditions.

For most materials the accuracy of the density and bulk modulus data obtained from such measurements is much higher than that obtained from isothermal dilatometric measurements. In the case of tellurium, the accuracies for the bulk modulus at 30 kbar are 1.6 and 23 percent, respectively.

Another interesting application of ultrasonics at high pressures is the detection of phase transitions and the measurement of the elastic properties as the material undergoes the transition. As an example for measurements through a transition range, our results of ultrasonic and isothermal dilatometric measurements on KCl are presented. We

find that the ratio of specific heats also shows a sharp increase in the transition range.

16030. Wegstein, J. H., **The automated classification and identification of fingerprints,** *Proc. Conf. on the Science of Fingerprints, London, England, Sept. 24-25, 1974*, pp. 49-67 (1974).

Key words: classification; computer; fingerprint; identification; pattern recognition; scanner.

Data read by the FBI's FINDER automatic fingerprint reader system must undergo three processing steps in order to achieve fingerprint identifications. First, the data must be "registered" to a standard reference position for subsequent comparison purposes. Next, the data are "classified" into suitable categories for filing and retrieval purposes. Finally, the data are "matched" against other fingerprint data of the same classification by comparing their distinctive minutiae. Computer algorithms for these processing steps are discussed and representative results presented.

16031. Haisch, B. M., Linsky, J. L., **Properties of the chromosphere-corona transition region in Capella,** *Astrophys. J.* **205,** No. 1, L39-L42 (Apr. 1, 1976).

Key words: stars, chromospheres; stars, late type; ultraviolet, spectra.

Analysis of recent ultraviolet observations of the Capella binary system (α Aur) indicates a dense, geometrically narrow chromosphere-corona transition region in the Capella system primary (G5 III) similar in many respects to a solar active region. An examination of the coronal energy balance, together with the coronal base pressure derived from the line fluxes, predicts a corona with a mean temperature of 1.2×10^6 K and a large stellar wind consistent with observations.

16032. Beitler, S. R., Armstrong, G. T., Domalski, E. S., Keane, T. R., Eds., **Book, Combustion Fundamentals for Waste Incineration,** 217 pages (The American Society of Mechanical Engineers, New York, NY, 1974).

Key words: combustion thermodynamics; enthalpies of formation; incinerators, industrial; thermodynamic data; waste disposal.

This monograph contains tabulated thermodynamic data for over 1300 substances needed by engineers for design and operation of incinerators for industrial wastes. In addition to tables of data, the monograph provides definitions of thermodynamic terms and a brief discussion of practical thermodynamic functions, a discussion of the calculation of thermochemical quantities related to combustion, and a brief discussion of the effect of temperature upon combustion processes and reaction equilibria. The monograph also contains annotated bibliographies containing selected references to (1) supplementary sources of thermodynamic information on chemical substances and materials, (2) methods of estimation of thermodynamic data, and (3) combustion and high temperature reaction equilibria. The principal table gives enthalpies of formation at 298.15 K for 989 organic compounds and inorganic carbon compounds listed in order of increasing empirical formula, and is accompanied by a name-formula index as an additional aid to locating data. Two other tables give enthalpies of formation at 298.15 K of 285 inorganic oxides and 39 organic polymers for which a reasonable formula could be assigned. An appendix at the end of the monograph gives supplementary information such as symbols for thermodynamic quantities, definitions of the SI base units, physical constants, and atomic weights.

16033. Burnett, E. D., **NBS hearing aid test procedures, Chapter III. Performance measurement data from the National Bureau of Standards,** *Handbook of Hearing and Measurement 1976*, **IB 11-52,** pp. 14-299 (Veterans Administration, Washington, DC, 1976).

Key words: anthropometric manikin; free-field measurements; hearing aid tests; orthotelephonic response.

This report discusses the current test procedures used by NBS to evaluate the electroacoustic properties of hearing aids. It includes the technical and practical reasons for performing the various tests in the manner described and in certain cases presents ideas and preliminary test methods for the evaluation of special-purpose hearing aids. However, the specific details of the electronic equipment used to perform the tests are not described.

16034. Evans, A. G., Johnson, H., **The fracture stress and its dependence on slow crack growth,** *J. Mater. Sci.* **10,** 214-222 (1975).

Key words: analytical predictions; constant stress rate; empirical measurements; fracture stress; slow crack growth.

An analysis is presented which enables the fracture strength, (under constant stress-rate conditions) to be predicted from fracture mechanics data obtained during slow crack growth—by identifying and evaluating several key parameters. The predicted strength characteristics are illustrated using fracture mechanics data obtained for a soda lime silicate glass. Finally, the predicted strengths are compared with strengths measured in flexure on abraded soda lime silicate glass specimens. A good correlation is obtained, indicating an equivalence between micro- and macro-crack propagation conditions for this material.

16035. Epstein, G. L., Reader, J., **Resonance lines and energy levels of Cs III, Ba IV, and La V,** *J. Opt. Soc. Am.* **66,** No. 6, 590-598 (June 1976).

Key words: barium; cesium; lanthanum; spectra; ultraviolet; wavelengths.

The spectra of Cs III, Ba IV, and La V have been observed in a sliding spark discharge on the 10.7 m normal-incidence vacuum spectrograph at NBS. Analysis of the observations of Cs III and La V has yielded the energy levels of the $5s^25p^5$ and $5s5p^6$ configurations and nearly all levels of the $5s^25p^45d$ and $5s^25p^46s$ configurations that can combine with the $5s^25p^5\ ^2P^\circ$ ground term. The observations for Ba IV have yielded the levels of the $5s^25p^5$ and $5s5p^6$ configurations. The $5s^25p^45d + 5s^25p^46s + 5s5p^6$ levels of Cs III and La V have been theoretically interpreted, with configuration interaction included. The energy parameters determined from a least-squares fit to the observed level values are compared with Hartree-Fock calculations. The ionization energies are found to be 33.38 ± 0.25 eV for Cs III, 47.1 ± 0.6 eV for Ba IV, and 61.6 ± 0.6 eV for La V. By extrapolating these values the ionization energy of Ce VI is estimated as 77.6 ± 1.2 eV.

16036. Albus, J. S., Evans, J. M., Jr., **A hierarchical structure for robot control,** *Proc. 5th Int. Symp. on Industrial Robots, Chicago, IL, Sept. 22-24, 1975*, pp. 231-238 (Society of Manufacturing Engineers, Dearborn, MI, 1975).

Key words: automatic control; automation; robots.

Sophisticated control of a mechanical manipulator is similar in many respects to the problem of organizing coordinated activity in any complex system with many degrees of freedom. It requires that the overall control problem be partitioned into manageable subproblems which can be arranged in a hierarchical control structure. At each level in the control hierarchy there exists a computing device or algorithm capable of accepting input commands from the next higher level, combining these with appropriate feedback signals from the controlled environment, and responding with an ordered sequence of output commands to the next lower level. Input to the top of the hierarchy commits the entire system to a specific goal-directed activity. Output from the bottom consists of strings of signal voltages which drive individual joint activators.

NBS has been evaluating ways in which such a hierarchical control structure can be implemented. One implementation is the Cerebellar Model Articulation Controller (CMAC), a memory-driven control element which can be used at each level in the control hierarchy to accept input commands from higher levels under feedback control. CMAC is a general purpose adaptive control function computer which can cope with many nonlinear feedback variables simultaneously, such as measurements of misalignment of parts, variable mass loading, irregularities in materials, and constraints imposed by an external environment.

NBS research in sensors and computer control systems will be described, with specific examples of applications for hierarchical control systems.

16037. McBee, C. L., Hastie, J. W., **Mechanistic studies of phosphorus containing flame retardants,** *Proc. 1975 Int. Symp. on Flammability and Fire Retardants, Montreal, Canada, May 22-23, 1975,* pp. 253-263 (Technomic Publication Co., Inc., Westport, CT, 1976).

Key words: flame retardancy; mass spectrometry; optical spectroscopy; phosphorus; polyester.

A combination of mass spectrometric and optical spectroscopic studies has been made to establish a mechanism for phosphorus controlled flame retardancy in thermoplastics. It is shown that a vapor phase mode of flame inhibition can account for the known flame retardancy effect of triphenylphosphine oxide in polyester substrates.

16038. Bagg, T. C., **A technological review: The future of microimagery in the library,** *Drexel Lib. Quart.* **11,** No. 4, 66-74 (Oct. 1975).

Key words: computer output microforms; information storage and retrieval; libraries; microfilm; microforms; micrographics.

Libraries are using microforms in a variety of ways and will add many more to their collections to save space, have available out-of-print materials, expand audiovisual materials and as the result of computer-generated microforms of frequently updated indexes, catalogs, listings, etc.

Despite the growing need of micrographic equipment, the libraries do not offer a large enough market to have equipment designed and produced by their specific needs. Libraries must therefore depend upon developments for other applications, some of which are discussed.

16039. Evans, A. G., Fuller, E. R., **Proof testing—The effects of slow crack growth,** *Mater. Sci. Eng.* **19,** No. 1, 69-77 (1975).

Key words: failure probabilities; lifetime assurance; proof testing; slow crack growth; unloading.

When slow crack growth occurs during proof testing, the extent of the crack growth while unloading from the proof stress has a substantial effect on the minimum predicted in-service failure time. It is essential that this crack growth is minimized to achieve effective failure prediction. Analyses are presented which show that the detrimental effects can be negated by environmental control during proof testing and/or rapid unloading from the proof stress; the requisite combination of unloading rate and environmental control is determined separately for each system.

16040. Henderson, M. M., **Copyright impacts of future technology,** (Proc. Symp. Centennial Meeting of the American Chemical Society, New York, NY, Apr. 5, 1976), *J. Chem. Inf. Comput. Sci.* **16,** No. 2, 72-74 (May 1976).

Key words: bibliographic data files; communications technology developments; computer developments; COM systems extension; copyright protection; facsimile transmission extension; photocopying; reprography developments.

Dynamic developments in computer and communication technologies, and in reprography and micrographics, are yielding systems and equipment that render better and faster access to information that has been copyrighted in traditional formats. Procedures and mechanisms must be worked out to permit us to take advantage of these technologies without destroying our basic systems of information dissemination.

16041. VanderHart, D. L., **Characterization of the methylene ^{13}C chemical shift tensor in the normal alkane n-$C_{20}H_{42}$,** *J. Chem. Phys.* **64,** No. 2, 830-834 (Jan. 15, 1976).

Key words: alkane; chemical shift tensor; methylene; NMR; ^{13}C.

^{13}C NMR chemical shifts in a single crystal of n-eicosane (n-$C_{20}H_{42}$) have been measured using the method of high power proton decoupling and the chemical shift tensors were characterized. Principal values in ppm relative to CS_2 are: (a) For CH_3: $\sigma_{11} = 166.7 \pm 2$, $\sigma_{22} = 171.2 \pm 2.0$, $\sigma_{33} = 189.8 \pm 2$; (b) For the α-methylene: $\sigma_{11} = 156.0 \pm 2.5$, $\sigma_{22} = 163.1 \pm 2.5$, $\sigma_{33} = 178.0 \pm 2.5$; and (c) For the interior methylenes: $\sigma_{11} = 142.6 \pm 2.0$, $\sigma_{22} = 154.6 \pm 2.0$, $\sigma_{33} = 175.6 \pm 2.0$. From x-ray studies, only the unit cell parameters are known. On the basis of isolated molecule symmetry considerations, cross-polarization rate studies, and oriented polyethylene spectra, the interior methylene chemical shift tensor is assigned with respect to molecular orientation. The crystallographic axes are also related to the interior methylene chemical shift tensor and a prediction is made for the $C-CH_3$ bond direction relative to these crystallographic axes. The principal axes of the α-CH_2 and the CH_3 chemical shift tensors do not coincide with any bond directions. The difference (5.6 ppm) between the interior methylene average chemical shielding in solid n-eicosane and the isotropic liquid value is also discussed.

16042. Norden, B. N., **National measurement system: Length and related dimensional measurements—A micro study,** *NCSL Newsletter* **15,** No. 2, 21-26 (June 1975).

Key words: dimensional measurements; length measurements; National Measurement System.

Studies of the National Measurement System are currently in progress at the National Bureau of Standards. These studies are an attempt to understand the infrastructure and impact of measurement throughout our economy. One particular micro study is entitled *Length and Related Dimensional Measurements.* This brief article gives an overview of the developments to date; i.e., description of the infrastructure, identification of various users, and discussion of needed future research in the area of length and related dimensional measurements.

16043. Hamer, W. J., **Standard cells,** Chapter in *The Primary Battery,* G. W. Heise and N. C. Cahoon, Eds., **I,** 433-477 (John Wiley & Sons, Inc., New York, NY, 1971).

Key words: batteries; cells, primary; dry cells; primary batteries; primary cells.

Testing procedures for primary cells and batteries are outlined. Emphasis is given to cells and batteries of the dry type. Tests are classified as (1) general tests, (2) initial tests, (3) service tests, and (4) shelf tests. Under initial tests measurements of open-circuit voltage, initial closed-circuit voltage, flash or short-circuit current, and internal resistance (or impedance) are considered. Methods that may be used to measure internal resistance are considered at length. Service tests include 28 standard tests as well as some other types of tests still in use. Some special tests as well as tests for wet primary cells and reserve batteries are briefly considered.

16044. Wets, R. J. B., Witzgall, C., **Towards an algebraic characterization of convex polyhedral cones,** *Numer. Math.* **12,** 134-138 (1968).

Key words: algebraic; cones; faces; Jordan-equivalent; matrices; polyhedral.

It is shown that the theory of positive linear independence and the properties of Jordan-equivalent matrices can be utilized effectively in order to obtain an algebraic characterization of a face structure of convex polyhedral cones.

16045. Pyke, T. N., Jr., **Assuring user service quality in a distributed computer network,** *Proc. COMPCON 76 Spring, San Francisco, CA, Feb. 24-27, 1976,* pp. 73-76 (IEEE Computer Society, Washington, DC, 1976).

Key words: computer networking; distributed networks; network service.

As users become dependent on service from multiple computer systems within distributed computer networks, a variety of problems arise in assuring that end user service quality is maintained. In this paper, a number of factors associated with user service quality are examined in the context of this trend toward distributed computing.

16046. Durig, J. R., Lafferty, W. J., Kalasinsky, V. F., **Spectra and structure of small-ring molecules. 33. Microwave spectrum of silacyclopentane,** *J. Phys. Chem.* **80,** No. 11, 1199-1202 (1976).

Key words: dipole moment; microwave spectrum; molecular structure; silacyclopentane; small-ring molecule; Stark effect.

The microwave spectrum of silacyclopentane, 1-silacyclopentane-*1,1-d*$_2$, and silacyclopentane-^{29}Si has been investigated in the spectral range of 8-40 GHz. The rotational lines of five vibrational excited states of the ring-puckering mode have also been assigned and are consistent with a high barrier to pseudorotation. Both the dipole moment measurements and the isotopic data indicate that the skeletal ring of this molecule is in the "twisted" C_2 conformation for the ground state. The *a* component of the dipole moment is 0.726 ± 0.005 D and the *c* component has been determined to be less than 0.01 D with a $|\mu_t| = 0.726 \pm 0.006$ D. The isotopic data are sufficient to determine the following parameters: $\angle HSiH = 108.76 \pm 0.26$, $r(Si-H) = 1.478 \pm 0.004$. Other important structural features have been estimated.

16047. Albus, J. S., Evans, J. M., Jr., **Robot systems,** *Sci. Am.* **234,** No. 2, 77-86B (Feb. 1976).

Key words: artificial intelligence; automation; computer control; manipulators; robots; robot systems.

This article reviews currently available industrial robots and research on robot systems. A hierarchical control structure concept, which is the basis for NBS research efforts in computer control systems, is used to provide a framework for this review.

16048. Branstad, M. A., Branstad, D. K., Jeffery, S., **Terminals: Out of sight but under control,** *Proc. COMPCON 74, San Francisco, CA, Feb. 26-28, 1974,* pp. 53-55 (IEEE Computer Society, Washington, DC, 1974).

Key words: security; terminals.

General purpose terminals, point-of-sale terminals, and cash dispensing terminals are described with respect to their common, as well as individual, security needs. Solutions which satisfy some terminal security requirements and needs for future security enhancements are presented.

16049. LeVanda, C., Bechgaard, K., Cowan, D. O., Mueller-Westerhoff, U. T., Eilbracht, P., Candela, G. A., Collins, R. L., **Bis(fulvalene)diiron, its mono- and dications. Intramolecular exchange interactions in a rigid system,** *J. Am. Chem. Soc.* **98,** No. 11, 3181-3187 (May 26, 1976).

Key words: biferrocenylene; delocalization; intramolecular exchange; magnetic susceptibility; mixed valence; Mössbauer spectra; optical.

Biferrocenylene [bis(fulvalene)diiron, BFD] was synthesized by two independent routes: an Ullman coupling of dibromoferrocene and the reaction of the fulvalene dianion with ferrous chloride. It was chemically oxidized to the mixed valence monocation and to the dication. These derivatives were characterized by optical, Mössbauer, ESR, and x-ray photoelectron spectra and magnetic susceptibility. The Mössbauer spectra of the mixed valence salts at 298 and 77 K indicate that both iron atoms are equivalent. X-ray photoelectron spectra similarly attest to this equivalence. An asymmetry in the intensity of the Mössbauer lines is due to a Karyagin effect. The Mössbauer spectrum of the dication shows a quadrupole splitting of 3.0 mm/s which is unusually large for a ferrocenium-type derivative. The magnetic susceptibility of BFD (2,3) picrate, measured in the 2-300 K range, follows a Curie law with a room temperature moment very close to the spin-only value. The dicationic fluoroborate salt is diamagnetic. The ESR spectra of the monocationic picrate and fluoroborate salts are characterized by narrow lines and a small rhombic anisotropy. An absorption in the near-infrared centered at 1550 nm is observed in the spectra of the monocations, but not the neutral or dicationic derivatives. The assignment of this band is discussed with respect to the results of the other physicalmeasurements.

16050. Ferraris, J. P., Finnegan, T. F., **Electric susceptibility and d.c. conductivity of crystalline TTF–TCNQ,** *Solid State Commun.* **18,** Nos. 9/10, 1169-1172 (1976).

Key words: d.c. conductivity; microwave conductivity; organic conductors; thermal expansion; TTF–TCNQ.

An experimental study has been made of the intrinsic d.c. and microwave conductivity of "high purity" crystalline TTF–TCNQ. The maximum normalized peak conductivity in each case was found to be about 50 times the room temperature value. The cavity perturbation technique, used to determine the microwave conductivity and low temperature dielectric constant, is also shown to be a useful contactless method for measuring the thermal expansion.

16051. Chang, T. T., Cohen, M. I., **Paramagnetic resonance of Dy^{3+} in CdF_2,** *J. Chem. Phys.* **64,** No. 12, 5255-5260 (June 15, 1976).

Key words: CdF_2; Dy^3; paramagnetic resonance.

Paramagnetic resonance of Dy^{3+} substitutional for Cd in CdF_2 was observed at 24 GHz and 4.2 K. The cubic spectrum and the orthorhombic spectrum of samples cross doped with Li, Na, or K were studied. The *g* factors are as follows: for the Γ_7 transition, $g = 7.4250$; for Γ_8 transitions in cubic symmetry, $g = 2.4514$: and for Γ_8 transitions in orthorhombic symmetry, $g_{110} = 2.1025$, $g_{001} = 8.6613$, and $g_{110} = 10.1846$.

16052. Mihalas, D., Shine, R. A., Kunasz, P. B., Hummer, D. G., **Resonance-line transfer with partial redistribution. VIII. Solution in the comoving frame for moving atmospheres,** *Astrophys. J.* **205,** No. 2, 492-498 (Apr. 15, 1976).

Key words: line formation; radiative transfer; stars: chromospheres.

An analysis of the effects of partial frequency redistribution in the scattering process for lines formed in moving atmospheres has been performed using a flexible and general method which allows solution of the transfer equation in the comoving frame of the gas. As a specific example, we consider the same chromospheric and atomic model, with the same velocity field, that was studied by Cannon and Vardavas. We find that the large changes in the profiles obtained by those authors, between the cases of complete and partial redistribution are *spurious effects of angle-averaging in the observer's frame instead of the comoving frame.* Our results support fully the conclusion by Magnan that these changes are, in fact, unreal, at least for this

particular model and redistribution function. Future work with other redistribution functions and with nonmonotone velocity fields will be possible using the techniques developed in this paper.

16053. Stevens, M. E., **Compatibility problems of network interfacing,** *Proc. Conf. on Interlibrary Communications and Information Networks, Warrenton, VA, Sept. 28-Oct. 2, 1970,* pp. 202-212 (American Library Association, Chicago, IL, 1971).

Key words: common practices; communication; compatibility; convertibility; information interchange; information networks; interfacing; interlibrary communication; man-machine interaction; network protocols.

The compatibility and convertibility problems of network interfacing are considered in the light of applicable standards, preferred common practices, and protocols. There is considerable emphasis upon requirements for interaction and information interchange. Specific technological problems of compatibility or convertibility at the interfaces between machine and machine, man and machine, and man and man are discussed. Promises for solution to at least the more tractable of the interfacing problems appear to lie in the growing conspicuity of these problems, the recognition of the need for compromise, a growing commitment to the usage of machines as aids to man, and the increasing impetus to cooperative action.

16054. Duff, J. W., Truhlar, D. G., **Classical *S* matrix: Application of the Bessel uniform approximation to a chemical reaction,** *Chem. Phys. Lett.* **40,** No. 2, 251-256 (June 1, 1976).

Key words: chemical reactions; classical scattering matrix theory; collision theory; hydrogen atoms; hydrogen molecules; scattering theory; trajectories; uniform approximation.

The Bessel uniform approximation developed by Stine and Marcus is applied to the collinear $H+H_2$ reaction on Diestler's potential energy surface no. 3 to which we have previously applied other orders of approximation of classical *S* matrix theory. It appears that an accurate treatment of this system by classical *S* matrix theory requires interference of real and complex trajectories. Calculations were also performed on two other potential energy surfaces in order to more clearly understand the interrelationships of previous semiclassical and quasiclassical studies of this reaction.

16055. Kuriyama, M., Boettinger, W. J., **On the angular divergence of out-going beams in an asymmetric diffraction geometry,** *Acta Cryst. A* **32,** Part 3, 511-512 (May 1976).

Key words: angular divergence; asymmetric diffraction; diffraction topography; dynamical diffraction; rocking curve.

The well-known relation for the angular divergence of beams diffracted from a perfect crystal in an asymmetric diffraction condition is derived straightforwardly from first principles.

16056. Geller, S. B., **Erasing myths about magnetic media,** *Datamation,* pp. 65-68, 70 (Mar. 1976).

Key words: data loss, magnetic media; devices, effects on magnetic media; fields, effects on magnetic media; magnetic fields, erasure of data; magnetic media, data erasure; magnetic media, data protection.

Magnetic media such as tapes and disks are used to store information for use in ADP systems. These stored data can be obliterated under certain conditions by fields which are produced by various devices. This paper describes the effects on data of devices which include airport metal detectors, x-ray units, radar systems, gamma rays, laser beams, television receivers, and automobiles. It describes the erasing effects of permanent magnets as well as the effects of varying magnetic fields, r. f. fields, light, heat, cold, and time on the stored data. The paper then presents some guidelines for safeguarding the data which are recorded on computer magnetic media.

16057. Morton, M., Fetters, L. J., **Homogeneous anionic polymerization of unsaturated monomers,** Chapter in *Macromolecular Reviews,* A. Peterlin, M. Goodman, S. Okamura, B. H. Zimm, and H. F. Mark, Eds., **2,** 71-113 (John Wiley & Sons, Inc., New York, NY, 1967).

Key words: block copolymers; homogeneous anionic polymerization; monodisperse polymers; unsaturated monomers.

This review discusses the polymerization of unsaturated monomers by carbanionic mechanisms. Particular emphasis is placed on the synthesis possibilities of these systems, i.e., monodisperse polymers, block copolymers, and polymers reactive end-groups.

16058. Saunders, R. D., Ott, W. R., **Spectral irradiance measurements: Effect of uv-produced fluorescence in integrating spheres,** *Appl. Opt.* **15,** No. 4, 827 (Apr. 1976).

Key words: deuterium, arc lamps; Halon; integrating spheres.

A fluorescence effect was detected when a Halon coated integrating sphere was irradiated by a deuterium lamp. This fluorescence, if not accounted for, causes large errors when comparing the spectral irradiance of tungsten lamps to that of deuterium lamps.

16059. Marshall, H. E., **Efficiency impacts of cost sharing on shoreline management,** *Coastal Zone Manage. J.* **2,** No. 4, 369-382 (1976).

Key words: beach erosion control; Corps of Engineers; cost sharing; efficiency; hurricane protection; shoreline management; shoreline protection.

The nation's shorelines are being eroded by high winds and waves. Nonfederal interests have traditionally received federal help in the form of cost sharing for protective structures. This article describes, compares, and evaluates existing and alternative cost-sharing rules for shoreline protection on the basis of economic efficiency. Both engineering and management techniques are examined for beach erosion, hurricane, and emergency coastal flood protection. The present cost-sharing system appears to bias local interests to choose (1) costly techniques of protection, e.g., engineering rather than management techniques, and under certain conditions (2) protective structures overbuilt in terms of the efficient scale. Conclusions are that these biases could be reduced if all engineering and management techniques for reducing shoreline damages were subject to the same percentage cost-sharing rules.

16060. McCulloh, K. E., Dibeler, V. H., **Enthalpy of formation of methyl and methylene radicals of photoionization studies of methane and ketene,** *J. Chem. Phys.* **64,** No. 11, 4445-4450 (June 1, 1976).

Key words: enthalpy of formation; ketene; methane; methyl; methylene; photoionization; rotational energy.

Photoion yield curves for CH_3^+ and CH_2^+ from methane have been measured near threshold at 295 and 115 °K, and the curves for CH_2^+ from ketene have been obtained at 295 and 130 °K. Although the detection efficiencies for positive and negative ions were nearly equal, a search for the ion-pair process yielding $CH_3^+ + H^-$ gave negative results. The methane data are successfully fitted on the assumption that the full rotational energy is available for formation of CH_3^+, but that only two rotational degrees of freedom contribute to the available energy for the process yielding CH_2^+. Neglecting excess energy at threshold, the values $\Delta Hf_0°(CH_3) = 149.4 \pm 0.5$ kJ/mole (35.70 ± 0.12 kcal/mole) and $\Delta Hf_0°(CH_2) = 392.5 \pm 2.1$ kJ/mole (93.8 ± 0.5 kcal/mole) from methane. Correction of the threshold for CH_2^+ from ketene for rotational energy results in the concordant value $\Delta Hf_0°(CH_2) = 390.8 \pm 1.7$ kJ/mole (93.4 ± 0.4 kcal/mole) on the assumption that excess energy can be neglected at threshold. The mean of the two determinations is selected as the preferred value $\Delta Hf_0°(CH_2) = 391.6 \pm 1.7$ kJ/mole (93.6 ± 0.4 kcal/mole).

16061. Thomas, G. A., Schafer, D. E., Wudl, F., Horn, P. M., Rimai, D., Cook, J. W., Glocker, D. A., Skove, M. J., Chu, C. W., Groff, R. P., Gillson, J. L., Wheland, R. C., Melby, L. R., Salamon, M. B., Craven, R. A., De Pasquali, G., Bloch, A. N., Cowan, D. O., Walatka, V. V., Pyle, R. E., Gemmer, R., Poehler, T. O., Johnson, G. R., Miles, M. G., Wilson, J. D., Ferraris, J. P., Finnegan, T. F., Warmack, R. J., Raaen, V. F., Jerome, D., **Electrical conductivity of tetrathiafulvalenium-tetracyanoquinodimethanide (TTF-TCNQ),** *Phys. Rev. B* **13,** No. 11, 5105-5110 (June 1, 1976).

Key words: electrical conductivity; organic conductors; tetrathiafulvalenium-tetracyanoquinodimethanide; TTF-TCNQ.

New measurements of electrical conductivity along the *b* axis of tetrathiafulvalenium-tetracyanoquinodimethanide (TTF-TCNQ) are combined with published results to provide a comprehensive summary including approximately 600 samples studied at 18 different laboratories. The magnitudes of these measured conductivities do not necessitate the assumption of superconducting fluctuations or any other collective state in which the conductivity exceeds the limitations of single-particle scattering. Since an adequate theory of the limitations of single-particle scattering for TTF-TCNQ does not exist at present, experiment alone does not rule out the possibility that collective effects may somewhat enhance or suppress the conductivity.

16062. Hughes, C. E., Walker, J. C., **POPSS, a system for modelling and analyzing operating system resource allocation strategies,** *Proc. 3rd Texas Conf. on Computing Systems, Austin, TX, Nov. 7-8, 1974, Paper 74-CHO895-3C,* pp. 3-6-1—3-6-8 (IEEE Computer Society Publ. Office, Long Beach, CA, 1974).

Key words: FORTRAN IV; operating system; overhead; resource allocation; simulator; strategies; workload.

This paper describes the parametric operating system simulator POPSS, a FORTRAN IV program which was designed to provide a tool for evaluating operating system resource allocation strategies and to serve as a pedagogical device, providing understanding of the functions, components, and component interactions of operating systems. In order to meet both these objectives the system was designed in such a way as to be both flexible and easy to use. The paper covers the range of resource allocation strategies which may be modelled; the facilities provided for describing workloads; the methods used to simulate operating system overhead; and the tools incorporated for allowing users to extend the range of models beyond those currently built into the system.

16063. Pyke, T. N., Jr., **Network access techniques: Some recent developments,** *Proc. 3rd Texas Conf. on Computing Systems, Austin, TX, Nov. 7-8, 1974, Paper 74-CHO895-3C,* pp. 2-2-1—2-2-4 (IEEE Computer Society Publ. Office, Long Beach, CA, 1974).

Key words: communication; computer networks; network access techniques.

Over the last few years a clear need to help computer network users more efficiently and effectively access network based resources has been recognized. This need has followed the demonstrated feasibility of large scale computer networks that provide a wide variety of resources. It has also resulted from the current availability of a large number of commercial, academic, and Government networks that provide a wide variety of programs, data, and systems resources for users. The functions performed by network access processes and devices that have been implemented or are planned range from basic communications support to applications-oriented capabilities. These functions can be performed within a network environment by techniques ranging from user support processes in host computers to minicomputer-based network access devices, as well as by intelligent terminals. Examples of these functions and of network architectures that support them are given in this paper.

16064. Evans, A. G., Russell, L. R., Richerson, D. W., **Slow crack growth in ceramic materials at elevated temperatures,** *Metall. Trans.* **6A,** 707-716 (Apr. 1975).

Key words: acoustic emission; crack propagation; cyclic conditions; failure times; high temperatures; silicon nitride; slow crack growth.

Techniques for studying slow crack growth at high temperatures are described. The techniques are used to obtain crack growth data for a range of silicon nitrides between 1100 and 1400 °C. For these materials the data suggest that the slow crack growth may be effectively characterized by the relation between crack velocity and stress intensity factor. Data obtained for mechanical and thermal fatigue modes indicate that these behaviors can be predicted with moderate accuracy from the isothermal, static stress parameters (for the range of conditions investigated). Finally, the application of slow crack growth data to failure prediction is described and illustrated using data for one of the materials tested.

16065. Pella, P. A., Kuehner, E. C., Cassatt, W. A., **Development of thin calibration standards for x-ray fluorescence analysis,** *Environmental Protection Technology Series, EPA-600/2-76-126,* 11 pages (Available as PB253252 from the National Technical Information Service, Springfield, VA 22161, May 1976).

Key words: calibration; filters; orchard leaves; standard reference sample; x-ray analysis.

Particulate reference samples have been prepared for the Environmental Protection Agency for use in the standardization of x-ray fluorescence spectrometers. Uniform layers of reground orchard leaves of known composition, i.e., NBS Standard Reference Material 1571, were deposited on membrane filters and coated with a thin polymer film. Samples have been prepared with deposit thicknesses ranging from 0.1 to 5.0 mg/cm^2.

16066. Washer, F. E., **Cameras, optics, and filters for color aerial photography. Lens design for color,** Chapter III in *Manual of Color Aerial Photography, First Edition,* J. T. Smith, Jr., Ed., 94-138 (American Society of Photogrammetry, Falls Church, VA, 1968).

Key words: lens aberrations; lens characteristics; lens distortion; lens resolving power.

This article presents a brief description of lens characteristics and aberrations that are of interest in photography. The various aberrations such as longitudinal spherical, longitudinal chromatic, and lateral chromatic are described together with brief discussions of their effect on imagery and some methods of measurement. Lens distortion, field curvature, and resolving power are also discussed briefly. Figures and tables illustrating various phases of lens performance are included.

16067. Garvin, D., Domalski, E. S., Hampson, R. F., Wagman, D. D., **Chemistry in the stratosphere,** Chapter 5 in *The Natural Stratosphere of 1974, CIAP Monograph 1,* A. J. Grobecker, Ed., Report No. DOT-TST-75-51, 28 pages (Dept. of Transportation, Washington, DC, Sept. 1975).

Key words: atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant.

This chapter has two objectives. They are (1) to illustrate the problems to be solved in unraveling the chemistry of the stratosphere and (2) to provide the quantitative data needed when chemical reactions are introduced into numerical modeling of the stratosphere. The topics discussed in this chapter, their pertinence to the stratosphere and some principal conclusions are described.

16068. Florin, R. E., **Leo Aloysius Wall,** Biographical item for book *American Chemists and Chemical Engineers,* W. D. Miles, Ed., pp. 490-491 (American Chemical Society, Washington, DC, 1976).

Key words: biography; Wall, L. A.

Short biography of Leo A. Wall.

16069. Evans, A. G., Wiederhorn, S. M., Linzer, M., Fuller, E. R., Jr., **Proof testing of porcelain insulators and application of acoustic emission,** *Am. Ceram. Soc. Bull.* **54,** No. 6, 576-581 (June 1975).

Key words: acoustic emission; macrocracking; porcelain insulators; proof testing; residual strain.

An investigation of proof testing has been conducted on large cone and post porcelain insulators. The cone configuration was unsuitable for overload proof testing to the loads needed for effective lifetime predictions. The only merit of subjecting this configuration to a proof test is the assurance of no immediate macrocracking during installation. This is achieved by testing to a load marginally larger than the service load. Conversely, the post configuration exhibited the basic prerequisites for effective proof testing but detailed stress analysis of this system is needed before specific proof testing procedures can be recommended. Finally, acoustic emission measurements were a major asset for monitoring both macrocracking events and stress development during the proof tests.

16070. Weikel, M. K., Miller, T. R., **A summary of a cost analysis of blood banking alternatives,** *Proc. 3rd Annual Conf. of the Society of Government Economists, Washington, DC, Mar. 23, 1973,* W. E. Kost, Ed., pp. 31-37 (1975).

Key words: blood banking; cost analysis; economics; indirect costs; subsidized costs.

A brief synopsis of parts of NBS Report 10 924, "Cost Analysis of Blood Banking Alternatives," was presented at the Third Annual Meeting of the Society of Government Economists. The presentation included discussion of: current problems related to blood banking; the economic aspects of blood supply and demand; the cost analysis methodology; and the actual results of the cost analysis.

16071. Huffman, J. C., Roth, R. S., Siedle, A. R., **Synthesis of ternary metal sulfide arrays,** *J. Am. Chem. Soc.* **98,** No. 14, 4340-4341 (July 7, 1976).

Key words: clusters; metal-metal bonding; metal sulfides; sulfides; tungsten; x-ray crystallography.

Deoxygenation of $(Ph_3PCH)_2WO_2S_2$ with Ph_2PCH_3 in the presence of a group Ib metal slat led to $[(Ph_2PCH_3)_2Cu]_2WS_4$, $[Ph_2PCH_3)_2Ag]_2WS_4$, $[(Ph_2PCH_3)Ag]_2WS_4$ and $[Ph_2PCH_3)Au]_2WS_4$. Infrared, Raman, electronic, ^1H and ^{31}P nmr spectral data are reported.

The gold-tungsten-sulfur array was characterized by single crystal x-ray diffraction techniques.

16072. Culver, C., **Fire loads and live loads in buildings,** *Proc. Int. Conf. on Performance of Building Structures, Glasgow, Scotland, Mar. 31-Apr. 1, 1976,* **1,** 111-119 (Pentech Press Ltd., London, England, 1976).

Key words: buildings; fire loads; load surveys; occupancy live loads; structural engineering.

The development of a nation-wide survey program for determining fire loads and live loads in buildings and establishing the factors which affect these loads is described. Considerations involved in planning the program and the type of data collected are included. Preliminary survey results obtained from the NBS Administration building are described.

16073. Manning, J. R., **Comparison of matrix inversion, Monte Carlo, and diffusion of probability techniques for calculation of diffusion correlation factors,** (Proc. Symp. on Computer Simulation for Materials Applications, Gaithersburg, MD, Apr. 19-21, 1976), *Nucl. Metall.* **20,** Pt. 1, 109-120 (Apr. 1976).

Key words: computer simulation; correlation factor for diffusion; diffusion; matrix calculation; Monte Carlo calculation; theory of diffusion; vacancy diffusion.

The diffusion correlation factor can be determined by calculating the mean square atom displacement resulting from a long series of atom jumps. Monte Carlo computer simulation techniques are coming more-and-more to be applied to this problem. Possible problems encountered in applying the common matrix inversion technique to correlation factor calculations are discussed, and the relative advantages and disadvantages of matrix inversion and Monte Carlo techniques are examined. In some cases, a diffusion of probability technique that involves only one matrix inversion is found to provide more nearly accurate results than do either the usual matrix inversion or Monte Carlo techniques. As examples, correlation approximations for diffusion in random binary alloys and for diffusion via divacancies are discussed.

16074. Farmer, B. L., Eby, R. K., **Calculations of internal friction resulting from molecular defects in hydrocarbon crystals,** (Proc. Symp. on Computer Simulation of Materials Applications, Gaithersburg, MD, Apr. 19-21, 1976), *Nucl. Metall.* **20,** Pt. 1, 154-165 (Apr. 1976).

Key words: calculations; hydrocarbon crystals; internal friction; molecular defects; pair potentials; site model.

Relaxations observed by dynamic-mechanical measurements of linear hydrocarbon crystals have been attributed to a variety of molecular features. In the present review, molecular defects resulting from the inclusion of isolated methyl-branched molecules and vacancies in the crystals are examined with regard to their possible roles in these relaxations. An approach combining the treatments of a standard linear solid, a site model, and molecular building with computer based semi-empirical potential energy calculations has been used. The results indicate that such molecular defects can indeed play a role in the observed relaxations. The relaxation strength and relaxation times determined from the computational model are in qualitative and semi-quantitative agreement with experimental data.

16075. Davis, R. M., **Federal interest in computer utilization by state and local governments,** *The Bureaucrat* **1,** No. 4, 349-356 (Winter 1972).

Key words: automation; computer utilization; dedicated computers; EDP expenditure; employment; finance; productivity; services—state/local government.

The size of state and local government labor forces, their expenditures on EDP, and nationwide desires for more government services of better quality provided with increased productivity are national concerns. The federal investment in state and local government EDP is significant. As a result, there is a legitimate interest in the effect federal policies may have on computer utilization by state and local governments. A review of federal policies shows that there is no single overall federal policy imposing any constraints on computer utilization by state and local governments. The Department of Justice in its National Crime Information Center (NCIC) has formulated security and confidentiality provisions applicable only for that system. No other federal agency appears to have policies specific to the dedicated use of computer systems.

16076. Henderson, M., Geddes, S., **Automation and the federal library community: Report on a survey,** *Federal Library*

Committee, pp. 1-49 (Library of Congress, Washington, DC, June 1973).

Key words: federal libraries; library automation; survey report.

From June 1970 to July 1971 an intensive investigation was undertaken of the federal library community and its involvement with library automation. The project, initiated by Federal Library Committee's Task Force on Automation of Library Operations, was supported by the U.S. Office of Education and conducted by the System Development Corporation. This report summarizes and abstracts the results of that investigation and highlights the resulting picture drawn of the federal library community. Tables and graphs from the original report and handbook are reproduced in this summary and are referred to the original documents.

16077. McKinney, J. E., Simha, R., **Configurational thermodynamic properties of polymer liquids and glasses. Poly(vinyl acetate). II,** *Macromolecules* **9,** No. 3, 430-441 (May-June 1976).

Key words: compressibility; configuration; entropy; heat capacity; holes; polymer; poly(vinyl acetate); pressure; thermal; volume.

The theoretical internal energy, entropy, and internal pressure of the equilibrium system of poly(vinyl acetate) using the scaling parameters established previously are computed as functions of temperature and pressure and found to be in good agreement with those derived from the experimental PVT data given in paper I. For the analysis of the glassy state, a new method is developed and applied to the two constant formation glasses discussed earlier. It employs the partition function which has the same mathematical form as for the equilibrium system, but derives the hole fraction $h(V, T)$ as the solution of a partial differential equation. This equation results from the proper thermodynamic definition of the pressure in terms of the partition function, applied to the experimental PVT surfaces for the glasses. A quantitative improvement in the compressional thermodynamic functions, particularly in regard to the internal pressure, ensues over the more empirical procedure employed previously. There h is treated as an adjustable parameter in the pressure equation derived for the liquid, using the experimental PVT surface for the glass. The application of the proper expression for the pressure results in a reduced variation of h with temperature and pressure in the glassy state and thus in numerically larger freezing fractions than those derived earlier. We exhibit the internal energy and entropy differences between the atmospheric pressure and pressurized (800 bar) glasses, and between these and the super-cooled melt. The computed difference between the configurational heat capacities of the melt and glass at T_g are about 47 percent for C_p and 13 percent for C_v of the totals obtained by calorimetry. Finally, convenient interpolation expressions for the hole fraction, theoretical internal energy, and theoretical entropy as functions of the reduced variables of state are developed for the equilibrium liquid in general and the two specific glasses considered here. These relations dispense with the necessity of iteration procedures for the numerical evaluation of the theoretical functions.

16078. Stein, R. J., **Angle- and energy-resolved charged particle spectroscopies—A simple way,** *Rev. Sci. Instrum.* **47,** No. 6, 716-719 (June 1976).

Key words: angle and energy distributions; charged particle spectroscopy; electron-stimulated desorption of ions (ESDIAD); field-ion microscopy (FIM); low energy electron diffraction (LEED); ultraviolet photoelectron spectroscopy (UPS).

The acquisition of angular and energy distribution information is of growing importance in a number of charged particle spectroscopies used for surface studies. A simple, inexpensive method is outlined for obtaining a visual display of angular distributions containing energy distribution information in the form of color. In essence, a detector optical bandpass is varied synchronously with an energy-selecting element of a spectrometer having a visual display in order to convert the analyzed particle energy distribution to a corresponding chromatic map. The primary utility of the method would be to obtain qualitative information rapidly in those cases where the particle energy spectra have distinct and strong features or when features of interest lie at the higher-energy end. Examples of the latter are plasma loss structure in low-energy electron diffraction, electron-stimulated desorption ion angular distributions, and the higher-energy structure in ultraviolet photoelectron spectroscopy. Other applications are also considered. The practical sensitivity limit for the case of visual observation is 1.0 percent $[I(\Delta E)/I_{total}]$. This sensitivity is not sufficient for application of the method to Auger electron spectroscopy or electron spectroscopy for chemical analysis.

16079. Penn, D. R., **Quantitative chemical analysis by ESCA,** *J. Electron Spectrosc. Relat. Phenom.* **9,** 29-40 (1976).

Key words: electron spectroscopy for chemical analysis; mean free path; quantitative analysis.

Electron spectroscopy for chemical analysis (ESCA) can be used as a quantitative tool for the determination of the chemical composition of the surface region of a solid if certain parameters are known. The least well known is the electron mean free path. We present values of the electron mean free path for inelastic scattering as a function of energy for all elemental solids (with the exception of the rare earths and the actinides) and we give formulae for the calculation of the mean free paths for compounds. It is shown that this information makes it possible to deduce from ESCA measurements the relative concentration of atoms or molecules distributed homogeneously in the surface region of a material.

16080. Watson, R. E., Herbst, J. F., Wilkins, J. W., **Core level shifts of rare-gas atoms implanted in the noble metals,** *Phys. Rev. B* **14,** No. 1, 18-25 (July 1, 1976).

Key words: core level; implant; noble metals; rare gas; shift.

By means of soft-x-ray photoemission Citrin and Hamann have observed core level shifts of Ne, Ar, Kr, and Xe atoms implanted in the noble metals and have constructed a theoretical model with which to interpret the results. We describe calculations employing a quite different approach to the same physical effects which are as successful numerically. The two salient elements are the energy associated with the screening of the core hole by the host-metal electrons and the potential shift arising from the surface dipole of the metal, neither of which is present in the free-atom case. Also considered is the chemical shift due to implantation in the host; estimates of this depend upon details of the model describing the implant site, but for the case at hand we find this contribution to be small.

16081. Hocken, R., Moldover, M. R., **Ising critical exponents in real fluids: An experiment,** *Phys. Rev. Lett.* **37,** No. 1, 29-32 (July 5, 1976).

Key words: CO_2; critical exponents; critical point; equation of state; SF_6; Xe.

We report precise optical measurements of the equations of state of Xe, SF_6, and CO_2 very near their critical points ($|T-T_c|/T_c < 5\times 10^{-3}$). We find that the critical exponents of these fluids in this region are close to the exponents calculated from the three-dimensional Ising model.

16082. Mariaenko, G., Huggett, R. J., Friend, D. G., **An instrument with internal calibration for monitoring chlorine residuals in natural waters,** *J. Fish. Res. Board Can.* **33,** No. 4, Part 1, 822-826 (1976).

Key words: amperometry; chlorine monitoring; chlorine residuals; coulometry; flux-monitor; water analysis; water pollution.

To increase the sensitivity of field instruments for measurement of low level chlorine concentrations in natural waters a new monitor was developed. Iodine, resulting from oxidation of potassium iodide by chlorine residual, is measured amperometrically in a system in which coulometrically generated iodine is used as a system calibrant. Laboratory tests, field tests, and comparisons of the new chlorine monitor with other instruments were performed. Data obtained with the new instrument show that chlorine concentrations down to a few parts per billion can be measured. The instrument is portable, and has built-in electrical calibration features and direct read-out display in either microamperes or parts per million of residual chlorine.

16083. Snell, J. E., **Comments on drainage system performance,** *Proc. CIB Commission W62 Symp. on Drainage Services in Buildings, National Swedish Institute for Building Research, Stockholm, Sweden, Sept. 24-25, 1973,* pp. 1:1-1:11 (Swedish Council for Building Research, Stockholm, Sweden, 1974).

Key words: gravity drainage evaluation; plumbing research.

A number of changes are taking place in plumbing system technology that may lead to significant departures from traditional dependence on gravity drainage. These factors include new designs and materials and the need to conserve water. A major concern in facilitating introduction of new technology is overcoming traditional roadblocks to innovation in this field. This paper describes an approach being pursued by the National Bureau of Standards and others to assure that performance of new systems is demonstrated in terms meaningful to local enforcement authorities.

16084. Siu, M. C. I., **Analysis of edge-heat-loss of a guarded-hot-plate apparatus,** *Proc. 14th Int. Conf. on Thermal Conductivity, Storrs, CT, June 2-4, 1975,* P. G. Klemans and T. K. Chu, Eds., pp. 413-422 (Plenum Press, NY, 1976).

Key words: ambient temperature index; edge-heat-loss; errors; guarded-hot-plate apparatus; line-heat-source; thermal conductivity.

Analysis on the error in measured specimen thermal conductivity arising from edge-heat-loss at the periphery of any guarded-hot-plate apparatus is presented. It is shown that the error due to edge-heat-loss varies linearly with respect to the deviation of the ambient temperature from mean specimen temperature. Explicit expressions are presented for the line-heat-source guarded-hot-plate apparatus being constructed at the National Bureau of Standards.

16085. Yates, J. T. , Jr., Madey, T. E., Erickson, N. E., Worley, S. D., **Adsorption and condensation of small molecules on tungsten (100) as studied using x-ray photoelectron spectroscopy,** *Chem. Phys. Lett.* **39,** No. 1, 113-117 (Apr. 1, 1976).

Key words: carbon dioxide; carbon monoxide; chemisorption; formaldehyde; oxygen; physisorption; surface chemistry; tungsten; x-ray photoelectron spectroscopy.

X-ray photoelectron spectroscopy (XPS) has been used to examine the adsorption of H_2CO, O_2, CO and CO_2 on the W(100) surface at 100 K and 300 K. Correlations between XPS measurements and kinetic measurements have been made.

16086. Winder, D. R., **Orientation of hexagonal crystals,** *Am. J. Phys.* **38,** No. 3, 319-326 (Mar. 1970).

Key words: crystallography, elementary; crystals, hexagonal; hexagonal crystals; hexagonal lattices.

Interplanar angles and stereographic projections are described for hexagonal structures. Graphs of the variations of some interplanar angles with c/a are given. The four systems of indexing hexagonal lattices are compared.

16087. Culver, C. G., **Comprehensive survey program for fire and live loads in buildings,** *Proc. Public Buildings Service International Conf. on Firesafety in High-Rise Buildings, Seattle, WA, Nov. 18, 1974,* pp. 1-30 (1974).

Key words: buildings; fires; loads; safety; surveys.

The development of a nation-wide survey program for determining fire loads and live loads in buildings and establishing the factors which affect these loads is described. Considerations involved in planning the program, the type of data collected and data processing procedures as well as a brief description of the data analysis are included.

16088. Oser, H. J., **An average distance,** Problem 75-12 in *Problems and Solutions* **18,** No. 3, 497-501 (July 1976).

Key words: average distance; distance; multiple integrals; transportation problem.

Take two unit squares and place them side by side so they form a rectangle two units wide and one unit high. Now choose a point A at random in the first square and, again at random, a point B in the second square. Then A and B will be a certain distance apart. Question: If we repeat the random choice of A and B many times, how far apart will they be on the average?

16089. Fechter, J. V., Jr., **Product safety and product performance research at the National Bureau of Standards,** *Proc. 6th Congress of the International Ergonomics Association "Old World, New World, One World," University of Maryland, College Park, MD, July 11-16, 1976,* pp. 136-140 (The Human Factors Society, Inc., Santa Monica, CA, July 1976).

Key words: human factors ergonomics; product performance; product safety; standards.

In 1974, the National Bureau of Standards established a Center for Consumer Product Technology to conduct product safety and product performance research. The Center's Human Factors Section operates a laboratory which is used for consumer product studies. While much of the Laboratory's equipment and instrumentation is fairly typical of other human factors laboratories, its configuration and application at NBS is unique. A study of cooking ranges is presented to illustrate how the facility is being used.

16090. Unassigned.

16091. Margulis, S. T., **The ICET testing program for the certification of engineering technicians,** *Prof. Eng.,* pp. 30-31 (Mar. 1976).

Key words: criteria; decision making; human systems; measuring instruments; research assistants; test device evaluation.

The Institute for the Certification of Engineering Technicians (ICET) certifies engineering technicians nationally. New criteria for voluntary certification have been instituted recently. Central to the approach is a new testing program to determine the technical competence of candidates. Those applying for Associate Engineering Technician or Engineering Technician status are required to pass a written examination; those applying for Senior Engineering Technician status must prepare a 5000-word technical essay.

The testing program is described and evaluated and special uses for the written examinations, which ICET proposes, are reviewed. Overall, the testing program suggests careful test development and a desire for continuing development. Tests appear to be technically sound. Plans for test evaluation, by ICET, will more clearly establish the strengths and weaknesses of the tests. Special uses for the tests—for assessing technical obsolescence as part of a continuing professional development program, and for helping candidates prepare for the written examination by completing a short version of the test, are commendable additions to the testing program.

16092. Burch, D. M., Peavy, B. A., Powell, F. J., **Experimental validation of the NBS load and indoor temperature prediction model,** *ASHRAE Trans.* **80,** Part 2, 291-310 (1974).

Key words: dynamic model; environmental chamber experiment; heating and cooling load computer program; heating load; masonry building.

Measurements of the dynamic heat transfer in an experimental masonry building were made in a large environmental chamber to explore the validity of a computer program developed at NBS for computing heating and cooling loads, and indoor air temperatures. The experimental structure was a one-room house 20 ft long, 20 ft wide, and 10 ft high with walls of solid concrete blocks and a flat roof made of reinforced precasts concrete slabs. The building was exposed to a diurnal temperature cycle for a series of tests where changes were made in fenestration, the amount and location of insulation, and the amount of indoor mass. The NBS computer program predicted both indoor air temperatures and heating loads that were in close agreement with the experimental data.

16093. Bordé, C. J., Hall, J. L., Kunasz, C. V., Hummer, D. G., **Saturated absorption line shape: Calculation of the transit-time broadening by a perturbation approach,** *Phys. Rev. A* **14,** No. 1, 236-263 (July 1976).

Key words: lasers; nonlinear spectroscopy; saturated absorption.

We present a third-order perturbation calculation of line shapes in laser spectroscopy based on the density-matrix formalism. The new feature of this theory is the inclusion of the Gaussian spatial structure of the laser beams. We study the linewidth as a function of relaxation and transit times. A shift is found when the wave fronts are not flat. General line-shape formulas are given as well as approximate formulas valid in various domains.

16094. Cheron, B., Scheps, R., Gallagher, A., **Continuum radiation and potentials of Tl-noble gas molecules,** *J. Chem. Phys.* **65,** No. 1, 326-335 (July 1, 1976).

Key words: molecules; radiation; thalium.

Continuum emission intensities on the extreme wings of the Tl resonance lines due to noble gas perturbers have been measured as a function of gas temperature. These spectra, due to the $B^2\Sigma_{1/2} - X\ 1/2$, $B^2\Sigma_{1/2} - X\ 3/2$, and $B^2\Sigma_{1/2} - A\ 1/2$ bands, are interpreted with the classical Franck-Condon principle to yield estimates of the $B^2\Sigma_{1/2}$, $A\ 1/2$, $X\ 3/2$, and $X\ 1/2$ potentials of Tl-noble gas molecules. As has been noted qualitatively in matrix isolation studies, the Group III elements form unusually stable diatomic bonds with the "inert" gases, e.g., we find Tl-Xe bound by ~300 cm^{-1}. The Tl-Xe system is an interesting visible, excimer laser candidate, as the molecular spectra extend very far into the red wings of the resonance lines.

16095. Niatel, M. T., Loftus, T. P., Oetzmann, W., **Comparison of exposure standards for ^{60}Co gamma rays,** *Metrologia* **11,** 17-23 (1975).

Key words: cobalt-60; exposure standard; international intercomparison.

Comparisons for ^{60}Co gamma rays between the exposure standards of the Bureau International des Poids et Mesures (BIPM), the National Bureau of Standards (NBS) and the Physikalisch-Technische Bundesanstalt (PTB) are reported. For measurements made at about one meter from the source, and if the same physical constants are used, the differences are 0.26 percent between the BIPM and NBS standards, and at most 0.4 percent between the BIPM standard and the PTB standard chambers. The differences are consistent with the estimated systematic uncertainties (≈0.5%).

The difference between the NBS standard and the PTB chamber measurements, as determined through the ratios of each to the BIPM chamber, ranges from 0.17 to 0.66 percent. The difference in exposure standards for NBS and PTB actually ranges from 0.48 to 0.97 percent, since different stopping power corrections are used by these two laboratories.

An indirect comparison of the BIPM and NBS standards indicates that the difference of 0.26 percent will increase to 0.55 percent at a distance of two meters.

16096. Guildner, L. A., Johnson, D. P., Jones, F. E., **Vapor pressure of water at its triple point: Highly accurate value,** *Science* **191,** 1261 (Mar. 26, 1976).

Key words: precision mercury manometer; triple point of water; vapor pressure of water.

The vapor pressure of water at its triple point was measured with greatly increased accuracy. The triple point was realized with newly designed equipment that enhanced the stability of the pressure and permitted any air released from solution to be removed by pumping. A diaphragm pressure transducer separated the water vapor from the helium used to transmit the pressure to the manometer. The pressure was measured with the National Bureau of Standards precision mercury manometer. The vapor pressure at the triple point was found to be 611.657 pascals with random uncertainties at the 99 percent confidence level of ± 0.010 pascal. The systematic errors are estimated to be relatively insignificant.

16097. Spencer, L. V., Eisenhauer, C., **Reflection of charged-particle beams at near-grazing incidence,** *Trans. Am. Nucl. Soc.* **23,** 609-610 (June 1976).

Key words: Albedo; angular distribution; backscatter; charged particles; Monte Carlo; reflection.

An analytic expression is given for the angular distribution of charged particles reflected from a surface for a near-grazing incident beam. This expression predicts the apparent specular reflection peak observed in experiments and Monte Carlo calculations.

16098. Novick, R., Sprott, G., Lucatorto, T., **Identification of the lowest metastable autoionizing level in Rb from rf spectroscopic studies,** *Phys. Rev. A* **14,** No. 1, 273-278 (July 1976).

Key words: atomic beam; autoionization; differential metastability; fine structure; inner shell excitation; rf spectroscopy; rubidium; Zeeman effect.

The lowest Rb metastable autoionizing level has been identified by a rf resonance measurement of the g factors of the various hyperfine sublevels. Of the two lowest-lying metastable state assignments, $4p^5(^2P)5s5p(^3P)^4D_{7/2}$ and $4p^54d(^3F)5s^4F_{9/2}$, only components of the $^4D_{7/2}$ were observed in the metastable beam. The atomic-beam resonance method employed resembles traditional methods except that it exploits the differential metastability of the fine-structure levels instead of magnetic deflection for state selection.

16099. Jeffery, S., Branstad, D. K., **Security considerations in software systems,** *Proc. 3d Texas Conf. on Computing Systems, Austin, TX, Nov. 7-8, 1974, Paper 74-CHO895-3C,* pp. 8-4-1 – 8-4-4 (IEEE Computer Society Publ. Office, Long Beach, CA, 1974).

Key words: security, software; software engineering; software systems.

Software engineering may well be the foundation upon which security of computer systems will be built for the near future. Self-protecting systems, those which have the internal mechanisms to prevent technical assaults on the computer system's integrity are needed to prevent the unauthorized modification or disclosure of information stored and processed within the system. While most time-shared or multi-programmed computer systems do incorporate rudimentary protection mechanisms which prevent accidental damage to the operating system and to other concurrently processing programs,

no general system has withstood the technical onslaught of penetration teams authorized to test its security features. The generic flaws found and analyzed by these penetration teams can be traced to poor design criteria and/or poor programming techniques. This paper discusses some of the fundamentals of software engineering needed to be used and extended in building secure computer systems.

16100. Armstrong, G. T., **Reaction calorimetry of fluorine and the thermochemistry of its compounds,** *L'Actualité Chimique*, pp. 5-14 (Feb. 1976).

Key words: bomb calorimetry with fluorine; enthalpy of formation, fluorides; flame calorimetry of fluorine and fluorides; procedures, experimental for handling fluorine.

The importance, the advantages, and the difficulties of using elemental fluorine for reaction calorimetry are discussed. Techniques developed at NBS for bomb calorimetry and gas flame calorimetry with elemental fluorine or fluorine-containing compounds as oxidizers are discussed together with their application to substances such as CF_4, BF_3, ClF, ClF_3 and refractory compounds such as B_4C. The accuracy achieved and the scope of possible measurements are discussed in relationship to the status of the thermochemistry of fluorine compounds.

16101. Beausoliel, R. W., Phillips, C. W., Snell, J. E., **Field investigation of natural gas pipeline accident, Canterbury Woods, Annandale, VA,** *Fire J.* **68,** No. 3, 77-84 (May 1974).

Key words: Annandale; field test; gas explosion; leak detection.

On the morning of March 24, 1972, in Annandale, Virginia, two homes were destroyed and a third home damaged by gas explosions and fires resulting from a construction accident that caused the gas main leak. The National Transportation Safety Board was responsible for investigating this accident and requested that the National Bureau of Standards assist them with their investigation by conducting a field test at the accident site.

The objective of the test was to determine how the natural gas entered the homes and the paths the gas followed from the leak to the homes. The premise of the NBS test was that if an air-tracer mixture could be detected at locations where natural gas was known to have escaped, then the original underground gas paths may still exist. A detailed test plan was developed to determine gas escape locations and paths. This plan included a simulation of the underground gas movement, excavation of various utility trenches, soil tests, and dismantling of the foundation wall of one of the destroyed homes. The equipment used to introduce the tracer into the ground near the original leak consisted of an air compressor, a tracer source (refrigerant R-12), air flow measuring, piping and control valves. Electronic catalytic leak detectors were used to detect the tracer in homes and elsewhere on the test site. The test results substantiated the basic test premise, and tracer was detected in the basements of the two destroyed homes and the damaged home, but not in the undamaged homes. From the results, it is concluded that gas traveled through rock rubble on the site and used as backfill in utility trenches containing the individual water and sewer lines to the destroyed/damaged homes and entered the homes through leaks in their concrete block foundations.

16102. Blevin, W. R., **Black coatings for thermal radiation detectors,** *Proc. Smithsonian-Eppley Symp. on Solar Radiation. Measurements and Instrumentation, Rockville, MD, Nov. 13-15, 1973*, pp. 18-31 (1973).

Key words: black coatings; detectors; radiometry; reflectances.

One of the most critical components of a thermal radiation detector is the black coating that serves to absorb the incident flux and then to conduct the heat to the underlying receiver. Methods for measuring the optical and thermal characteristics of black coatings are reviewed, and results are given for a few different types of coating. The effect of the thermal characteristics of the coating on the detector responsivity is discussed, for both steady and modulated beams of radiation, and the related correction that is required with electrically calibrated detectors is described.

16103. Buhl, D., Snyder, L. E., Lovas, F. J., Johnson, D. R., **Is there a maser in the silicon monoxide ground state?,** *Astrophys. J.* **201,** No. 1, L29-L31 (Oct. 1, 1975).

Key words: circumstellar shells; masers.

Observations of the ground state ($v=0, J=2-1$) transition of silicon monoxide (SiO) show a rather smooth, low-intensity profile stretching over a large velocity range. The presence of ground-state emission at velocities which are not present in the $v=1$ or $v=2$ lines is interpreted as thermal emission in the ground state in regions where there is insufficient excitation to produce the vibrationally excited masers. Only VY CMa shows a profile which could be interpreted as ground-state maser emission.

16104. Cali, J. P., **Rationale for reference methods in clinical chemistry,** (Proc. Symp. 9th Int. Congress on Clinical Chemistry, Toronto, Canada, July 13-18, 1975), Paper in *Pure and Applied Chemistry* **45,** 63-68 (Pergamon Press, Ltd., Headington Hill Hall, Oxford, OX3 United Kingdom, 1976).

Key words: definitive method; matrix reference materials; pure reference materials; reference methods; routine methods; secondary reference materials; Standard Reference Materials.

In the field of clinical chemistry evidence is mounting that a reliable and medically relevant structure can be built on the concept of compatibility through accuracy in measurement. By compatibility is meant the ability of all laboratories in a network to achieve on a given sample similar and reliable numerical values for a property under test. It is shown that when all laboratories in a network are making accurate measurements, i.e., free of sytematic error and precise, then compatibility automatically ensues. The need for accurate measurement based on medical arguments is given.

In order to build an accurate measurement network, three measurement methodology levels and three types of reference materials are required. A *definitive method* is directly able to realize or to have access to the base or derived units of the measurement system. It depends in part on the availability of *pure reference materials* (e.g., those supplied by the National Bureau of Standards and called SRM's). At the next level are *reference methods* and *matrix reference materials*. These methods and materials are more adapted to implementation and use by clinical reference laboratories and the manufacturers of *secondary reference materials*. In turn these materials are used at the local level to control the quality and accuracy of the *routine methods*. How this hierarchy of methods and reference materials is structured is discussed.

The role of the definitive method is discussed in some detail, because of its crucial place in the structure. Potentially useful definitive methods, both for inorganic and organic constituents are outlined. A discussion of reference method developments, per se, is left to the other three authors of this Symposium (qv). Clinical SRM's now available are listed, as well as those now in preparation at NBS. The need for matrix reference materials is stated.

Finally, how this measurement network should be structured and implemented together with suggested organizations responsible for the various levels is discussed.

16105. Unassigned.

16106. Horowitz, E., **Standardization of plastics,** *Encycl. Polym. Sci. Technol.* **12,** 771-786 (1970).

Key words: plastics standardization; specifications; standards; standards organization; test methods.

This paper briefly discusses various organizations engaged in promoting, developing and promulgating standards, specifications, test methods and related documents in the field of plastics. In some cases the procedure for preparing standards and specifications, and the mechanism for their adoption is described. Examples are given of the types of standards and specifications that are available as well as the different classes of plastics materials that are covered. Plastics standardization activities at both the national and international levels are treated and references to the literature are provided.

16107. Kashiwagi, T., Newman, D. L., **Flame spread over an inclined thin fuel surface,** *Combust. Flame* **26,** 163-177 (1976).

Key words: flame spread; instability; radiant flux; α-cellulose.

Downward flame spread velocity over a thin α-cellulose sheet was measured from the vertical to the horizontal positions under external radiant fluxes of 0, 0.9, 1.4 and 2.0 W/cm^2. The flame spread velocity had little dependency on the angle of inclination of the sheet with the stable lower flame. When the lower flame became unstable, wavy flames, cellular flames and flame rolls were observed below the lower surface. With these unstable lower flames, the flame spread velocity increased significantly reaching several cm/s. Qualitative analysis based on the Rayleigh instability mechanism describes well the effects of the inclination angle and the external flux on the instability of the lower flame.

16108. McCaffrey, B. J., Heskestad, G., **A robust bidirectional low-velocity probe for flame and fire application,** *Combust. Flame Brief Communications* **26,** 125-127 (1976).

Key words: angular insensitivity; fluidic device; hot wire anemometer; ion deflection device; laser Doppler anemometer; Reynolds number.

A robust bidirectional flow measuring device has been evaluated and appears to have significant advantages over a pitot-static tube for use in fire research studies. Three different diameter probes were used to secure a low Reynolds number calibration needed for accurate assessment at very low velocities. The bidirectional capability is illustrated by an example of the use of the probe in a scale model corridor-burn room facility.

16109. McNesby, J. R., **New techniques for the measurement of air pollutants,** *Proc. Int. Symp. on Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Paris, France, June 1974,* Paper No. 47, 1-15 (1974).

Key words: ambient air; automotive emissions; laser magnetic resonance technique; stack emissions.

Measurement research in air pollution at the National Bureau of Standards includes that applicable to ambient air, stack emissions, and automotive emissions. Some of the measurement techniques developed for source emission application have been refined and made sufficiently sensitive to measure pollutant concentrations as low as background levels. The fluorescence monitor for sulfur dioxide developed by Dr. Okabe and his colleagues has been applied commercially to the problem of stack monitoring. More recently the sensitivity of the technique has been improved very substantially so that ambient air sulfur dioxide concentrations can be measured at least down to 1 part in 10^9. This apparatus will be described and its capabilities delineated. The technique of laser magnetic resonance for the measurement of NO at concentrations typical of stack emission and auto exhaust has similarly been extended to include ambient concentrations. In addition, progress has been made in the direction of simultaneous measurement of NO_2 by the same technique. The most recent data obtained by the laser magnetic resonance technique will be presented. A third measurement technique developed at the National Bureau of Standards, that of dual angle, forward laser scattering for the real time measurement of particle size distribution has now been shown to be capable of revealing morphological and chemical information. The development of pyrolysis as an alternative to permeation tubes and standard gas cylinders will be described. The principle of the pyrolytic technique is that a thermally stable molecule which may be stored indefinitely is subjected to thermal decomposition producing a nonstorable molecular species plus an exactly equal number of storable, readily measured molecular species. The pyrolytic technique has the inherent capability of tying together virtually all gaseous pollutant molecules in a single, self-consistent measurement and calibration scheme.

Finally, an absolute coulometric technique for the determination of parts per million concentrations of NO in nitrogen will be described. The technique has been used to generate confirmatory evidence for establishing the integrity of NO in nitrogen Standard Reference Materials.

16110. Mears, T. W., **NBS Standard reference materials: Their characterization and stability consideration,** *Proc. of the SAMA Calibrator Product Class Standard Forum and Stability Testing Workshop, Chicago, IL, Mar. 18-19, 1975,* 10 pages (Scientific Apparatus Makers Association, Washington, DC 20036, 1975).

Key words: accelerated testing; clinical; hazards; legal problem packaging; shipping; stability; standard reference materials.

The NBS Office of Standard Reference Materials issues some 800 standard reference materials. The mode of operation developed over the past 75 years relating to testing, certification, and elimination of errors is described. With the inclusion of organic and clinical materials in the program, new considerations were necessary. Packaging techniques were changed. Stability, particularly accelerated testing has become a real problem. The handling and shipping of potentially hazardous materials is more apparent. Finally, in the clinical area, the SRM program has come under the purview of the Food & Drug Administration. The facing and solving of these new problems are described.

16111. Robertson, A. F., **Potential heat: Considerations in the application of a new fire test,** *Fire Mater.* **1,** No. 1, 9-13 (Mar. 1976).

Key words: building materials; calorimetry; combustibility; flammability; heat release rate; potential heat; self heating.

A review is presented of the nature of the potential heat test method. It is emphasized that the procedure usually yields a property-type measurement of the material or composite when applied. As a result, care must be taken to insure that necessary supplementary tests are performed by other methods to guarantee that a substantial fraction of the possible fire hazard has been considered. Suggestions for appropriate use of the procedure are included and information available on the precision of the procedure is reviewed. It is concluded that, when properly applied, the procedure can serve well as one of the tools for characterizing possible fire hazards. Suggestions are made for possible future development of the procedure to yield information on rate of heat release.

16112. Rockett, J. A., **Fire induced gas flow in an enclosure,** *Combust. Sci. Technol.* **12,** 165-175 (1976).

Key words: fire; fire plume gas flow; room fires.

The gas flow induced by a small fire in a large room is considered. The fire plume acts as a pump and the window opening as a throttle. Generalizations of Kawagoe's expressions for the window air flow and height of the neutral plane are developed and used to rationalize previously unexplained features of Gross and Robertson's enclosure fire data.

16113. Benjamin, I. A., **Problems in the correlation of small and large scale tests,** *Proc. Int. Symp. on Fire Safety of Combustible Materials, Edinburgh, Scotland, Oct. 15-17, 1975,* **1,** 141-148 (1975).

Key words: fire tests; regulatory tests; simulation tests.

This paper attempts to show that there are problems in defining large scale tests: the validity of the large scale test is no better than the scenario chosen for its conduct. A review of the literature shows that the small scale tests now being used to evaluate wall and ceiling linings do not measure well what they are designed to measure. Future small scale tests should be derived from studies of large scale tests which are designed to determine the properties to be measured. The small scale tests will then show better correlation to large scale tests.

16114. Eisenhart, C., **Samuel Stanley Wilks,** *Dictionary of Scientific Biography* **XIV,** 381-386 (Charles Scribner's Sons, New York, NY, 1976).

Key words: *Annals of Mathematical Statistics;* bibliography; distribution-free methods; educational testing; mathematical statistics; multivariate analysis; order statistics; social sciences, services to; statistical education in the United States; statistical tolerance limits; U.S. Army programs in statistics; U.S. Government, services to; Wilks award; Wilks, S. S.

A review of the life and work of Samuel Stanley Wilks (1906-1964). His impact on the development of mathematical statistics; and on the development of statistical education in the United States. His services to the U.S. Government, and to the social sciences. Bibliography of principal original works; and of major secondary literature.

16115. Eisenhart, C., **William John Youden,** *Dictionary of Scientific Biography* **XIV,** 552-557 (Charles Scribner's Sons, New York, NY, 1976).

Key words: calibration designs; chain blocks; collaborative tests; diagnostic tests, index for rating; experiment design, statistical; graphical diagnosis; interlaboratory tests; randomization, constrained; ruggedness test; statistical techniques; Youden plot; Youden squares; Youden, W. J.

A review of the life and work of William John Youden (1900-1971). His invention of new techniques for statistical design of experiments and for analysis of data from individual experiments and from groups of experiments. Bibliography of principal original works; and of major secondary literature.

16116. French, J. C., **The ARPA/IC/NBS Semiconductor Technology Program,** *Proc. Space System Microelectronics Seminar, Los Angeles, CA, Apr. 15-16, 1975,* pp. 189-199 (The Aerospace Corp., Los Angeles, CA, July 31, 1975).

Key words: automation; integrated circuits; measurements; microelectronics; process control; reliability; semiconductor.

Reliable devices at lower cost, available when needed, are essential to the achievement of Department of Defense (DoD) systems objectives. The ARPA/IC/NBS Program, Advancement of Reliability, Processing, and Automation for Integrated Circuits with the National Bureau of Standards, supported by ARPA and conducted by NBS, reflects an emphasis on in-process measurements to achieve these objectives. Rather than following only the more traditional and costly approach of tested-in reliability, this program provides a new and complementary thrust directed toward the goal of built-in reliability through design control of fabrication, and automation. The concepts and approaches of this program are based on the experience gained in over a decade of activity in the NBS Semiconductor Technology Program and the transfer of the results obtained in this program to the industry with substantial benefit to both the industry and to DoD. Topics selected for attention cover key processing and assembly steps, from control of incoming materials to evaluation of electrical characteristics and packaging. The selection of topics for consideration is based on extensive field surveys, workshops, and direct interaction with industry and other agencies to determine the measurement needs both for manufacturing and marketplace interactions. An important factor in the program is continued close interaction with the industry to ensure transfer of the results of the program to the industry for use by the semiconductor integrated circuit manufacturer, his suppliers, and customers. Both in-house studies at NBS and efforts contracted out-of-house to industry, universities, and other government laboratories are being utilized.

16117. Judd, D. B., Nickerson, D., **Relation between Munsell and Swedish Natural Color System scales,** *J. Opt. Soc. Am.* **65,** No. 1, 85-90 (Jan. 1975).

Key words: color; colorimetry.

The degree to which Munsell hue, value, chroma and the Swedish Natural Color System variables of blackness, whiteness, redness, yellowness, greenness, blueness describe the same color space is shown by simple formulas.

16118. Kusuda, T., **NBSLD-National Bureau of Standards heating and cooling load determination program,** *APEC J.* **VIII,** No. 6, 4-11 (Winter 1973-1974).

Key words: computer program for buildings; conduction transfer functions; heating and cooling load; National Bureau of Standards load determination procedure.

A comprehensive treatment of building heat transfer processes has been incorporated into a computer program called NBSLD in order to study the effect of various building parameters upon the resulting heating and cooling load. The basis of the computation in the program is the detailed solution of simultaneous heat balance equations at all of the interior surfaces of a room or space. Transient heat conduction through the exterior walls and in the interior structures is handled by using ASHRAE type conduction transfer functions. The use of heat balance equations, although more time consuming for the calculation, avoids uncertainties inherent in a weighting factor approach. Thus, precision is improved for a specific building design. Described in this paper are some of the salient features of NBSLD and results of sample calculations which demonstrate the capability of this computer program.

16119. Goldman, A. J., **Discussion,** (Proc. Symp. on Systems Analysis for Social Problems, Gaithersburg, MD, May 26-28, 1969), Paper in *Systems Analysis for Social Problems,* A. Blumstein, et al., Eds., pp. 93-103 (Washington Operations Research Council, Washington, DC, 1970).

Key words: operations research; systems analysis; urban problems.

The increasingly "solid" quality of some recent applications of systems-analysis (SA) techniques to urban problems is noted. Particular emphasis is suggested on the city's success in performing those special functions for which it is peculiarly suited. The conflicting goals of and the struggle for scarce resources among urban interests are observed to be antithetical to SA's penchant for "optimizing" formulations; urban problems admitting such "clean" treatment are held unlikely to be among the underlying difficulties of our cities, but may provide suitable starts for analysis. Concern is voiced that city "institutionalization" of SA may inhibit its search for bold solutions.

16120. Powell, F. J., **Research on energy conservation in building at the National Bureau of Standards,** (Proc. Conf. on Buildings and the Environment, Cary Arboretum of New York Botanical Garden, Millbrook, NY, Nov. 1974), Chapter 6 in *Buildings and the Environment,* R. Goodland, Ed., pp. 114-140 (Cary Arboretum, Millbrook, NY, 1976).

Key words: buildings energy; energy conservation; NBS programs.

Selected topics of the National Bureau of Standards energy conservation program related to buildings are discussed. Topics included are the National Bureau of Standards Load Determination Computer Program (NBSLD) for estimating building energy consumption, the experimental results of tests on a masonry and a woodframe house, the status of an experiment on a mobile home, the study to retrofit an existing house on the NBS grounds to save energy, the experiment to retrofit a townhouse with solar collectors and storage systems to supply 75 percent of the annual energy needs of the townhouse, the energy conservation demonstration office building at Manchester, New Hampshire, and a new energy conservation school in New York City. Other energy conservation efforts are named by title only.

16121. McNesby, J. R., **Air pollution monitoring instrumentation,** *Proc. Naval Environmental Protection Data Base Instrumentation Workshop, Port Hueneme, CA, July 11-12, 1972,* pp. 150-155 (Naval Civil Engineering Laboratory, Port Hueneme, CA, 1972).

Key words: carbon monoxide; hydrocarbons; measurement; nitrogen dioxide; particulate matter; photochemical oxidants; standards; sulfur dioxide.

The first fundamental of air pollution abatement in the U.S. is that all U.S. residents are entitled to breathe air of at least standard quality. The standard quality is spelled out in the National Ambient Air Quality Standards. Secondly, the states are responsible for achieving this quality.

The states must answer these questions: How bad is the air quality now? How much do we have to improve it? To answer the first question we must measure the present levels of the pollutants sulfur dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, photochemical oxidants and particulate matter. The second question is answered by studying the quantitative relationship between ambient air pollutant concentrations and the amounts of pollutants emitted by the various source (modeling). This in turn requires measurement of pollutants emitted through smoke stacks and auto exhausts.

Without accurate methods of measurement, auto manufacturers cannot know their progress towards a low emission vehicle and cannot be sure of their progress relative to that of their competitors. Power plants cannot determine the efficiency of scrubbing devices; cities and states cannot determine if they are successfully implementing their ambient air goals.

16122. Riley, M. E., Truhlar, D. G., **Effects of the Pauli principle on electron scattering by open-shell targets,** *J. Chem. Phys.* **65,** No. 2, 792-800 (July 15, 1976).

Key words: electron exchange; electron scattering; hydrogen atoms; indistinguishable particles; phase shifts; quantum mechanics; scattering theory; semiclassical approximation.

The semiclassical exchange approximation and three free-electron-gas exchange approximations are applied to electron scattering from the hydrogen atom. In the triplet spin state the results are similar to our previous findings [M. E. Riley and D. G. Truhlar, J. Chem. Phys. **63,** 2182 (1975)] for electron scattering by closed-shell atoms. However these results, already of useful accuracy, are improved by the inclusion of one-electron exchange terms or an orthogonality constraint. For the singlet spin state it is essential to include the one-electron exchange terms except at high impact energies (greater than about 50 eV). The approximation of Lippmann, Schey, Burke, and Chandra for treating the triplet spin state and exchange with closed-shell targets is tested and found to be less accurate than the present approximations.

16123. Robertson, A. F., **Estimating smoke production during building fires,** *Fire Technol.* **11,** No. 2, 80-94 (May 1975).

Key words: building; estimating; fire; furniture; hazard; interior finish; smoke.

In the absence of specific analytical methods for measuring the hazards of fire gases, there is a trend toward the use of smoke production as a partial measure of this hazard. It is indicated that prediction of smoke concentrations and thus photometric properties during actual fires requires many important and rather critical assumptions.

16124. Robertson, A. F., **Test method categorization and fire hazard standards,** *ASTM Stand. News* **3,** No. 11, 18-20 (Nov. 1975).

Key words: ASTM; classification; fire hazard; participation; property; system; test method.

A general discussion is presented with the objective of distinguishing between different levels of test method complexity. It is suggested useful to understand the possibility of participation between the specimen and test equipment. A further distinction is proposed between property and system type tests as well as the usual classification on the basis of whether the specimen is destroyed or not. It is shown that fire test methods may be of either the property or system type, although often they are of the destructive participative system type the most complex of those discussed. Both the developers and users of tests are cautioned to recognize and observe the different ways in which it is appropriate to use property and system type test methods. Those responsible for development of such test methods are cautioned against the delivery of methods with the aura of system methodology but lacking in technical validity for the intended use.

16125. Robertson, A. F., **Two smoke test methods—A comparison of data,** *Fire Technol.* **10,** No. 4, 282-286 (Nov. 1974).

Key words: fire propagation test; fire tests; smoke density chamber; smoke tests; test comparison; UK; USA.

Smoke test methods have been developed in both UK and USA which are based on photometric measurements of smoke accumulation in closed chambers. The British Fire Research Station (FRS) procedure makes use of a large room approximately 37 times the volume of the box type chamber used in the test developed at the National Bureau of Standards (NBS). Tests have been conducted to compare the ability of the two measurement methods to assess smoke production from samples of selected materials. It is concluded that similar smoke measurements are obtained by use of the NMS procedure and use of the NBS specimen pyrolysis equipment in the room used for the FRS test. Moreover, there is general correspondence of the NBS and FRS smoke characterization results for many materials. However, these two methods tend to yield different results for high fuel content materials when the limited air circulation permitted by the FRS furnace becomes important, and for thermoplastic materials which in the FRS test melt and reticulate from heat exposure and do not burn. The findings suggest that the FRS method may be more sensitive to system effects of fire within an enclosure. Questions are raised as to whether the system simulated by the FRS test is the appropriate one.

16126. Sinha, S., Bardsley, J. N., **Symmetric charge transfer in low-energy ion-atom collisions,** *Phys. Rev. A* **14,** No. 1, 104-113 (July 1976).

Key words: alkali ions; calcium; charge exchange; charge transfer; cross section calculations; ion-atom collisions; rare-gas ions; uranium.

Previous calculations of ion-atom interactions by the pseudopotential and asymptotic methods are used in the computation of the cross section for symmetric charge transfer at energies below 1 keV. The results for Li^+, Na^+, K^+, Rb^+, Cs^+, and Ca^+ ions are compared with data obtained in beam experiments, and by optical-pumping techniques. The difference in the cross sections for $^2P_{1/2}$ and $^2P_{3/2}$ ions of Kr^+ and Xe^+ at thermal energies is studied, and the predictions are compared with recent mobility measurements. Cross sec-

tions are obtained for U^+-U collisions, and the dependence of the thermal cross section on the polarizability is described. Symmetric charge transfer of the negative ions H^-, Na^-, and Cs^- is discussed briefly.

16127. Stein, M. L., **A saddlepoint theorem for self-dual linear systems,** *Linear Algebra and Appl.* **9,** 55-65 (1974).

Key words: combinatorial equivalence; linear inequalities; linear programs; pivot operations; skewsymmetry.

Let A be a skew matrix of order n over an ordered field. There is a finite class of skew matrices $\bar{A}$ such that $XA = Y$ and $\bar{X}\bar{A} = \bar{Y}$ have the same solution sets, where $\bar{x}_i = y_i$ and $\bar{y}_i = x_i$ for some indices i (perhaps none) and $\bar{x}_i = x_i$, $\bar{y}_i = y_i$ for the remaining i. We show that for each index h, $1 \leqq h \leqq n$, there exists an $\bar{A}$ such that $\bar{a}_{hj} \geqq 0$ for all j. There are a variety of applications to matrix games, linear programs and related topics.

16128. Walston, W. H., Federman, C., **Fourier transform techniques for the calibration of shock accelerometers,** (Proc. 21st Int. Instrumentation Symp. on Instrumentation in the Aerospace Industry, Philadelphia, PA, May 19-21, 1975), Paper in Vol. 21 *Instrumentation in the Aerospace Industry* and Vol. 12 *Advances in Test Measurement,* B. Washburn, Ed., pp. 315-321 (Instrument Society of America, Pittsburgh, PA, 1975).

Key words: accelerometer; calibration; FFT; Fourier transform; Fourier transform frequency; mechanical shock; shock generator.

Calibration of mechanical shock accelerometers is accomplished by a shock comparison method which utilizes fast Fourier transform (FFT) techniques. This procedure computes sensitivity values at any frequencies desired over the entire calibration bandwidth. Pitfalls associated with the application of the FFT to actual shock pulses along with possible solutions are discussed. Close agreement with conventional sinusoidal calibration is obtained.

16129. Snell, J. E., Achenbach, P. R., Petersen, S. R., **Energy conservation in new housing design,** *Science* **192,** No. 4246, 1305-1311 (June 25, 1976).

Key words: energy conservation; energy efficient design; life-cycle cost models; new housing.

The combined influences of rising fuel prices and a national goal of energy independence are providing strong impetus to the consideration of energy conservation in design features in housing. This paper examines the potential implications of these influences to new housing design over the balance of this century. A life-cycle cost model is presented and used to estimate the influence of conservation and fuel price increase on a number of major housing design parameters. These parameters include housing type and size, thermal resistance, location, heating and cooling system capacity and efficiency. Next, the technological realities of achieving such changes are examined and the anticipated impacts of energy conservation on new housing design are summarized. It is felt that the principal emphasis will be on smaller more efficient dwellings, mechanical systems, and equipment with essentially improved overall performance utilizing technology readily available to the building industry.

16130. McNesby, J. R., **Problems in the measurement of free radical concentrations in the atmosphere,** *Ber. Bunsenges. Phys. Chem.* **78,** No. 2, 158-162 (1974).

Key words: chemical kinetics; free radicals; measurement; stratosphere.

The free radicals known, or suspected to be present in the earth's stratosphere have been listed by Garvin and Hampson and include O, O_2, SO, H, OH, HO_2, CH, CHO, CH_3, CH_3O, CH_3O_2, NH, NH_2, HNO, NO, NO_2, NO_3. In the urban troposphere near ground level, this list can be greatly expanded to include many species resulting from reactions of these simple radicals with reactive hydrocarbons. Since the economical control of air pollution requires a detailed knowledge of the chemical kinetics involved in removal of stable pollutant molecules from the air, it is desirable ultimately to be able to measure the concentrations and rate constants of all such reactants. I have selected from this list the two most abundant, polar atmospheric free radicals, NO andNO_2 for discussion. The ground states of NO, $^2\pi$ and of NO_2, $^2A_1$, qualify both molecules as free radicals. These molecules pollute the urban atmosphere and the stratosphere and the debates about the amounts in which they are present have precipitated major controversies in the United States and elsewhere. My purpose is to present the nature of the tropospheric problem of NO and NO_2 (known collectively in the trade as NO_x) why their measurement is important, the current state of the art and finally some of the newer approaches to the solution to the problem in terms of the basic Federal legislation in the United States, the Clean Air Act.

16131. Broussalian, V. L., **Risk measurement and safety standards in consumer products,** (Proc. Conf. on Research in Income and Wealth, Washington, DC, Nov. 30-Dec. 1, 1973), Paper in *Household Production and Consumption,* N. E. Terleckyj, Ed., **40,** 491-524 (National Bureau of Economic Research, New York, NY, 1976).

Key words: consumer products; product safety; refrigerator standards; risk measurement; safety standard; unreasonable hazards.

A definition of unreasonableness of a hazard is proposed. Although formally stated in economic terms, it calls for data of different kinds: engineering, political, psychological, legal, etc. Unreasonableness of a hazard is also related to injury avoidance actions which might be taken by consumers as well as by producers. To demonstrate how the definition may be used in practice, it is applied to an actual hazard for which a mandatory safety standard has been set. This example is the well-known refrigerator entrapment hazard. Finally, the risk data needed to determine whether a hazard is reasonable or not are indicated.

16132. Cooper, J. W., **High-energy dependence of the molecular-hydrogen photoionization cross section,** *Phys. Rev. A* **9,** No. 5, 2236-2237 (May 1974).

Key words: hydrogen; molecular cross section; photoeffect.

The photoionization cross section for H_2 per atom has recently been reported to be ~45 percent larger than the atomic cross section at energies of 5.41 and 8.39 keV. This note relates this observation to the differences in electron density at the nucleus in atomic and molecular hydrogen and points out that the enhancement at high photon energies is unique for molecular hydrogen.

16133. Ekberg, J. O., **Term analysis of Fe VI ,** *Phys. Scr.* **11,** No. 1, 23-30 (1975).

Key words: iron; spectra; ultraviolet; wavelengths.

The spectrum of Fe VI has been observed by using a vacuum sliding-spark discharge and the 10.7-m grazing-incidence spectrograph and the 10.7-m normal-incidence spectrograph at the National Bureau of Standards, Washington. More than 400 lines have been classified in the region 250-1 580 Å. All terms of the configurations $3d^3$, $3d^24s$ and $3d^24p$, except $3d^2(^1S)4s^2S$ have been established. The estimated uncertainty of the level values is ± 0.4 cm^{-1}. The $3d^3$, $3d^24s$ and $3d^24p$ level structure has been theoretically interpreted. The energy parameters determined from a least-squares fit of the observed level values are compared with Hartree-Fock calculations. From the complete set of $3d^3$ levels all forbidden lines of Fe VI from 1 387 to 10 000 Å have been predicted. All but two lines in the spectrum of the star RR Telescopii previously identified as forbidden Fe VI lines have been confirmed and 6 of the otherwise unexplained lines have been identified as [Fe VI].

16134. Epstein, G. L., Reader, J., **Spectrum of doubly ionized yttrium (Y III),** *J. Opt. Soc. Am.* **65,** No. 3, 310-314 (Mar. 1975).

Key words: spectra; ultraviolet; wavelengths; yttrium; zirconium.

The spectrum of doubly ionized yttrium was observed from 600 to 9700 Å by means of plane- and concave-grating spectrographs at NBS. About 100 new lines were observed. From these measurements, 40 new energy levels were derived. The known level system (Rb I isoelectronic sequence, $4p^6nl$) now includes the series ns (n=5-9), np (n=5-9), nd (n=4-8), nf (n=4-10), ng (n=5-8), and nh (n=6-8). The nf series shows irregular fine-structure splittings, $4f$ having a negative splitting of about 3 cm^{-1}. The ionization energy of Y III was determined to be 165 540.5 ± 1.0 cm^{-1} (20.52457 ± 0.00012 eV). A re-examination of Kiess's data for Zr IV in the light of the Y III analysis yielded a revised value for the ionization energy of Zr IV of 277 550 ± 20 cm^{-1} (34.412 ± 0.003 eV).

16135. Geist, J., Dewey, H. J., Lind, M. A., **Low-level periodic pulsed energy measurements with an electrically calibrated pyroelectric detector,** *Appl. Phys. Lett.* **28,** No. 4, 171-173 (Feb. 15, 1976).

Key words: electrically calibrated pyroelectric detector; gold-black; piezoelectric; pulse laser power.

The use of an electrically calibrated pyroelectric detector for accurately measuring periodically pulsed (~3-ns duration) energy with an average power level in the microwatt to milliwatt range was investigated. Sources of error especially important in this application were the pyroelectric's acoustic response, its linearity, and possible deterioration of its gold black coating. The detector had a thin polymer film that isolated the radiation receiver from the pyroelectric material. This film temporally resolved the pyroelectric response from the piezoelectric response to the acoustic energy that is associated with the absorption of an impulse of energy. Thus it was demonstrated that the acoustic response was not a serious source of error. The film also reduced the requirement of linearity on the pyroelectric transducer by about 5 orders of magnitude from the conditions of a bare transducer. It is concluded that periodic pulsed energy measurements with 5 percent uncertainties are readily achievable with the detector described.

16136. Meisters, M., **Concepts and trends in polymer fire testing,** *Mod. Plast.* **52,** No. 9, 76-78, 81-82 (Sept. 1975).

Key words: fire performance tests; flame spread; heat input; heat release rate; limiting oxygen index; radiant panel; smoke density; time to ignition.

This report provides a framework for understanding the principles that are important in correlating small- and large-scale tests in terms of such fire concepts as ignition, propagation, heat release, and smoke generation. All of the methods have limitations and cannot completely evaluate fire performance, but they offer a baseline for continued development of tests to provide better correlations with real-fire performance.

16137. Hamilton, W. C., Edmonds, J. W., Tippe, A., Rush, J. J., **Methyl group rotation and the low temperature transition in hexamethylbenzene. A neutron diffraction study,** *Discuss. Faraday Soc.* **48,** 192-204 (1969).

Key words: barrier to rotation; crystal; crystal structure; hexamethylbenzene; hindered rotation; phase transition; torsional oscillation; λ-point.

Neutron diffraction studies of single crystals of hexamethylbenzene at 298 K and at 130 K indicate that the molecule in phase II has approximate D_{3d} symmetry. The amplitudes of libration of the methyl group and of rigid body motions of the molecule are consistent with earlier data, except that the barrier to methyl group rotation appears to be lower by about 0.5 kcal/mol (2100 J/mol).

Consideration of intra- and inter-molecular hydrogen atom contact distances and calculated potential energy curves using a 6-exp potential function suggest that intermolecular forces are important in determining the barrier to rotation of the methyl groups and that substantial changes in the intermolecular packing must be responsible for the lambda-point transition at 116 K and the consequent profound change in the potential barrier to internal rotation which has been previously observed.

16138. Tsai, D. H., MacDonald, R. A., **Molecular dynamical studies of energy transport in a crystalline solid,** (Proc. Symp. on Computer Simulation for Materials Applications, Gaithersburg, MD, Apr. 10-21, 1976), *Nucl. Metall.* **20,** Pt. 1, 489-509 (Apr. 1976).

Key words: anharmonic crystal; computer simulation; energy transport; heat pulse; interatomic potential; molecular dynamics; second sound; shock wave; stress wave; temperature wave; thermal diffusivity; thermal relaxation.

We review the main results of a series of molecular dynamical studies of the transport of energy in a crystalline solid subjected to heating and to shock compression. Our model is a perfect semi-infinite bcc lattice. We use a two-body interatomic potential which simulates that in α-iron. The classical equations of motion for the atoms are solved numerically under appropriate initial and boundary conditions, and the properties of the lattice and the transport of energy are determined from averages of the atomic motion. We find that a disturbance in thermal energy propagates either by diffusion or as a temperature wave with second sound velocity. A disturbance in potential energy propagates as a stress wave with first sound velocity. These results are in agreement with experiments. In addition, we find that longitudinal and transverse stress waves generate their own temperature waves through thermalization of the kinetic energy change accompanying the stress disturbances. The significance of this thermal relaxation process to the interpretation of heat pulse and shock wave experiments is examined.

16139. Tovey, H., **The development of the National Fire Data System,** *Fire J.* **68,** No. 6, 91-96 (Nov. 1974).

Key words: fire data; fire hazard; fire injuries; fire investigation; fire loss; fire reporting; fires.

The development of the National Fire Data System is described. The major policy requirements established for the system are listed, and four specific categories of fire data needs are defined. The system itself is described in terms of inputs, structure, and outputs, and the system users are classified and described. A report on the current status of the system development effort is given, covering projects on the fire incident reporting subsystem, the national household survey of fire experience, statistical summary data tapes, fire technology information, detailed hazard analyses, and integrated system outputs.

16140. Young, R. D., **Instrumentation for the chemical analysis of manufactured surfaces,** *Ann. CIRP* **24,** No. 2, 549-554 (Aug. 1975).

Key words: surface; surface finish; surface roughness measurement.

Over the last twenty years a wide variety of analytical instruments for studying the chemical composition of surfaces have been developed, many of which are commercially available. Several of these instruments lend themselves to the analysis of the practical surfaces encountered in manufacturing processes, thus contributing to our understanding of the process, and the integrity of the fabricated surface.

Three particularly useful techniques include ESCA, Auger and the electron microprobe. In ESCA (electron spectroscopy for chemical analysis) nearly monochromatic x-rays of about 1000 eV energy impinge on the specimen surface. Photoelectrons produced in atoms of

the top nanometer are energy analyzed to yield spectra which are characteristic of these surface atoms. In the Auger technique, high-energy electrons bombard the specimen surface, generating Auger electron emission which is characteristic of the surface atoms. This instrument if often combined with LEED (low energy electron diffraction), enabling measurement of the atomic arrangement of the surface atoms which are analyzed with Auger emission.

A highly attractive though less well developed technique called infrared reflection (absorption) could conceivably be used on-line to detect the presence of certain chemicals on surfaces. The scanning electron microscope (SEM) has been combined with the electron microprobe (EMP) in order to determine the micro-distribution of materials over a surface. In the microprobe a high energy electron beam stimulates characteristic x-ray emission from surface atoms. Application of these techniques to fabricated surfaces will be discussed.

16141. Edelman, S., **Piezoelectric polymer stress gages,** *Proc. Symp. on Advancements in Instrumentation for Civil Engineering Applications, Kirtland Air Force Base, NM, May 9-10, 1973,* Technical Report No. AFWL-TR-73-186, pp. 221-224 (Air Force Weapons Laboratory, Kirtland Air Force Base, NM, Oct. 1973).

Key words: piezoelectric; polymeric transducer; polymers; polyvinyl fluoride; polyvinylidene fluoride; stress gages; transducers.

Gradual improvement in material selection and poling techniques has developed polymers with significant piezoelectric activity. This material can now be used to make many kinds of instruments for measuring dynamic stress, pressure, vibration, etc. Polymers that can be made piezoelectrically active are available with a wide variety of mechanical, electrical, and chemical properties. They can be formed in size and shape to suit a particular application and they can be fastened to curved, twisted or compliant surfaces. Sensors in the form of thin sheets, coaxial cables, and hollow tubing have been made.

16142. Eliason, L. K., **Standards for door security,** *Archit. Met.* **21,** No. 3, 6-7 (June 1976).

Key words: building codes; door assemblies; performance requirements; physical security; standards.

This article discusses the need for standards for the physical security of door assemblies, describes the nature and application of NILECJ-STD-0306.00, "Physical Security of Door Assemblies and Components," and suggests the manner in which the standard can be utilized to improve the security of door assembly components. The implementation of the standard within local building codes is also addressed.

16143. Evans, J. M., Jr., **Position sensors and computer control techniques for automatic control of agricultural vehicles,** *Proc. IFAC Symp. on Automatic Control for Agriculture, Saskatoon, Saskatchewan, Canada, June 18-20, 1974,* Dr. G. C. Zoerb, Ed., Preprint Sec. A-2, pp. 1-5 (Agricultural Engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, 1974).

Key words: agriculture; computer control; position sensors; RF interferometer.

RF interferometers may be used for determination of position and orientation of vehicles to an accuracy of millimeters over distances to thousands of meters. Servo control may be implemented through mini- or micro-computers using read-only memory for the control functions. The application of these techniques to the control of agricultural vehicles is discussed.

16144. Krasny, J. F., **Development of flammability standards,** *Proc. 3d Symp. on Textile Flammability, New York, NY, Apr. 16-17, 1975,* pp. 30-46 (LeBlanc Research Corp., East Greenwich, RI, 1975).

Key words: apparel; burn injury; carpets; draperies; fabrics; flammability; heat flux; standards; tents; tests; uniforms; upholstered furniture.

The activities of the Center for Fire Research of the National Bureau of Standards in the area of textile item flammability standards are described. Work is in progress on a general apparel flammability standard, to replace CS 191-53. A test concept involving a cylindrical fabric specimen, and measurement of the ignitability and the heat release to the inside of the cylinder, is under development. A draft standard for the flammability of upholstered furniture was submitted to the Consumer Product Safety Commission. It consists of a fabric-screening test and test of mock-ups of the fabric, stuffing, tape, etc., arranged as in the furniture piece to be tested. A flooring systems test, to provide a reasonable substitute for the tunnel test, is applicable also to carpets. It consists of exposing a sample to radiation varying in intensity over the specimen length. The specimen is pilot ignited at the high radiation end, and the distance burned until the flames extinguish is measured. This distance can be converted to the "critical radiant flux" as a measure of potential hazard. Studies are also in progress on curtains and draperies, tents, and flight attendant uniforms.

16145. McHenry, H. I., **Ship steel weldments for low temperature service,** *Weld. J.* **55,** No. 5, 387-393 (May 1976).

Key words: alloying; inclusions; low temperature; rolling; ships; steel; welding.

The ship steels, welding practices and weldment toughness requirements applicable to low temperature (to −46 °C) regions of liquefied-natural-gas (LNG) tankers are reviewed. In the construction of LNG ships, the principal welding productivity problem is the low deposition rate associated with the low heat input welding practices required to provide sufficient toughness in the weld heat-affected-zone (HAZ). A potential solution to this problem is to use improved steels which can be welded using efficient procedures and still provide satisfactory HAZ toughness. The steelmaking practices that contribute to low temperature toughness are reviewed with respect to economic limitations associated with ship steels and to their potential for improving HAZ toughness.

16146. Meissner, P., Evans, J. M., **Computer-aided design in manufacturing,** (Proc. Technology Workshops, Lafayette, IN, Oct. 3-6, 1973 and Columbus, OH, Nov. 7-10, 1973), Paper in *The Automation Research Council,* A. Seireg, Ed., Report No. 5, pp. 289-303 (The American Automatic Control Council, Holmdel, NJ 07733, Feb. 1974).

Key words: CAD; CAD/CAM; computer-aided design; manufacturing.

This review of the use of computer-aided design in manufacturing is based primarily on the experiences of General Motors, McDonnell Douglas, and the Army Electronics Command. The paper provides a common base for discussions by representatives of Government, industry, and universities attending two Workshops on the Technologies of Automation sponsored by the Automation Research Council of the American Automatic Control Council. The material illustrates the current state-of-the-art in CAD, including available hardware and software, and the economics and time savings of existing CAD systems.

16147. Mitchell, R. A., Woolley, R. M., Baker, S. M., **Finite element simulation of weldbonded joint deformation,** (Proc. Symp. on Computer Simulation for Materials Applications, Gaithersburg, MD, Apr. 19-21, 1976), *Nucl. Metall.* **20,** Pt. 2, 1039-1050 (Apr. 1976).

Key words: bonded joints; computer simulation; cyclic loading; debond analysis; finite element analysis; joints; nonlinear analysis; single-lap-joint bending; spotwelded joints; weldbonded joints.

Finite element computer techniques are described that simulate the structural response of weldbonded single-lap and double-lap joints. The techniques also apply equally well to the special case of a bonded joint without spotwelds. A planform analysis articulates the in-plane deformation of the joined sheet material and the lap-shear stresses acting through the spotwelds and the adhesive. A longitudinal cross-section analysis computes out-of-plane bending effects, particularly important in single-lap joints, and adhesive peel stresses. Algorithms are described that simulate several nonlinear modes of response by sequences of linear solutions. Single-lap joint specimens of eight different configurations, designed so as to constitute an experimental parameter study, were instrumented with resistance strain gages and tested in the laboratory. For the most part, strains measured on the surfaces of these specimens were in reasonably good agreement with the finite element simulations, provided out-of-plane bending effects were accounted for.

16148. Collard, J. J., **Is the proposed Federal Standard for brakes adequate for police patrol vehicles?,** *Proc. SAE Automotive Engineering Congress and Exposition, Detroit, MI, Feb. 24-28, 1975,* Paper No. 750399, pp. 1-6 (Society of Automotive Engineers, Inc., Warrendale, PA, 1975).

Key words: FMVSS 105a; LAPD brake tests; NBS survey; patrolcar brakes; patrolcar survey; police brake requirements.

In 1972, the National Bureau of Standards surveyed 530 police departments to determine what was wrong with their patrolcars: 449 departments responded to the survey. Thirty-two percent of the respondents, a plurality, identified brakes as the most dangerous feature, and 36 percent identified it as the system most in need of standards. Ninety-four percent of the respondents rated their patrolcar brakes excellent to satisfactory at speeds under 70 mph (113 kph), but 25 percent rated them poor over 70 mph. While the new Federal Motor Vehicle Safety Standard 105-75 may improve the brake systems for patrolcars for routine, low speed use with frequent applications, it will be necessary to continue testing patrolcar brakes under severe driving conditions to assure reliability at high speeds.

16149. Krasny, J. F., Francis, J. B., **Ranking extinguishability of burning fabrics,** *J. Am. Ass. Text. Chem. Color.* **6,** No. 6, 135-136 (June 1974).

Key words: cotton fabrics; extinguishability; flammability; polyester/cotton fabrics.

This report describes initial efforts to obtain laboratory data on the relative extinguishability of various fabrics, an aspect of the hazard due to burning fabrics which has been largely neglected in the past. A simple apparatus was designed to simulate the extinction of burning fabrics by beating the flames out. Two plates covered with asbestos sheeting are brought together at a rapid rate after a fabric suspended between them comes to a full burn. The time the plates have to be held together to extinguish the flames was found to increase roughly with increasing fabric weight. For a given weight, the time to extinguish tended to be shorter for all-cotton fabrics than for polyester/cotton blends; the blends also tended to stick to the plates.

16150. Parker, W. J., **The large-scale fire-test facility at the National Bureau of Standards,** *Proc. Symp. on Full-Scale Fire Tests, Lancaster, PA, Nov. 11-12, 1974,* pp. 45-48 (1976).

Key words: construction; corridor test; fire endurance furnace; fire growth; heat release; smoke abatement; sprinkler system.

The newly completed fire-test facility at the Gaithersburg site of the National Bureau of Standards provides the capability of studying the fire endurance of columns, walls, and floor/ceiling assemblies; fire growth and control in rooms; fire spread and control in corridors; and smoke movement in buildings. The study of fire growth in a room is concentrated on the role of the furnishings, as well as the interior finishing materials. A burn room is also available to examine the fire-buildup process in a large item of furniture.

16151. Reed, W. P., **Radioisotope and radiopharmaceutical standards,** *Proc. San Diego Biomedical Symp., San Diego, CA, Feb. 6-8, 1974,* **13,** 507-509 (1974).

Key words: biomedical; clinical; measurements system; radioisotopes; radiopharmaceuticals; reference sources; standards; SRM's.

A previous paper by J. P. Cali described meaningful measurements and the components that go into a meaningful measurement system. This paper examines one of the NBS programs in the measurement system and how this system relates to the biomedical profession.

At NBS the Radioactivity Section under the supervision of Dr. W. B. Mann is responsible for relating our national measurement system and standards for radioactivity to the international measurement system. This activity has three aspects of interest here: (1) SRM's that are available to all and are related to the national measurement system. (2) An industry-government cooperative program for the improvement and standardization of commercial radiopharmaceuticals and other reference sources. (3) A training and interlaboratory comparison program for the education of clinical personnel in the measurement of radioactive materials, including the calibration of devices commonly used to measure radiopharmaceutical doses.

These three aspects of this program help to stabilize the measurement system, i.e., help to make meaningful measurement. Each of these efforts is discussed in detail to improve the understanding of interactions between the national laboratory and laboratories or groups in the field making these measurements, and to clarify the interaction between individuals and the system.

16152. Powell, F. J., Kusuda, T., Hill, J. E., **Occupant comfort as a decision-making concept for air conditioning of buildings,** (Proc. CIB Commission W45 (Human Requirements) Symp. on Thermal Comfort and Moderate Heat Stress, Watford, England, Sept. 13-15, 1972), Paper in *Thermal Comfort and Moderate Heat Stress,* pp. 191-215 (Her Majesty's Stationery Office, London ECIV 3RN, England, 1973).

Key words: air conditioning criteria; human comfort; physiological indices; predicted indoor habitability index (PIHI); weather building human systems.

A rationale for improving air-conditioning criteria is given. A new research approach and concept are presented. The concept is to include in criteria the effect of the building envelope and the response of humans to the resultant indoor temperature and relative humidity in addition to weather data which are normally used to make decisions concerning air conditioning for buildings. The concept involves generation of a "Predicted Indoor Habitability Index" (PIHI) as a means to evaluate the response of occupants to short-term as well as long-term exposure in non-air-conditioned housing. The work completed thus far is described.

The results of a pilot study for two locations, Jersey City, New Jersey and Macon, Georgia, are presented to demonstrate the feasibility of the concept. The indoor temperature and humidity were determined by calculation using a computerized simulation technique which follows a detailed heat transfer analysis of the weather/building/human-body systems. The calculated results were used to compute the value of several available physiological indices to reveal the extent and duration of undesirable indoor conditions when the apartment was not air conditioned. Statistical correlations between indoor and outdoor conditions were prepared as a means to reduce the amount of computation for establishing criteria.

16153. Schaefgen, J. R., **Integrating community utilities for resource conservation,** *Proc. Third National Conf. on Complete Water Reuse: Symbiosis as a Means of Abatement for Multi-Media Pollution, Cincinnati, OH, June 27-30, 1976,* pp. 53-59 (1976).

Key words: community services; cooling; electric power; energy conservation; heating; incineration; integrated utility systems; resource conservation; utilities; utility services; water reuse.

A Modular Integrated Utility System (MIUS) provides the utility services of electrical power, space heating and cooling, potable water heating, solid waste processing, sanitary sewage treatment, potable water treatment, and the site distribution, collection, and disposal functions attendant thereto. MIUS facilities are constructed on a community scale to achieve the maximum symbiotic effects from process integration. The MIUS approach to utility services can conserve energy, reduce environmental degradation, and permit greater flexibility in intensive land development at a competitive cost. A demonstration design is being initiated to quantify the performance and evaluate the synergistic benefits of multi-service facilities.

16154. Slater, P. J., **Leaves of trees,** (Proc. 6th Southeastern Conf. on Combinatorics, Graph Theory, and Computing, Boca Raton, FL, Feb. 17-20, 1975), Paper in *Proceedings of the Sixth Southeastern Conference on Combinatorics, Graph Theory, and Computing,* F. Hoffman, R. C. Mullin, R. B. Levow, D. Roselle, R. G. Stanton, and R. S. D. Thomas, Eds., pp. 549-559 (Utilitas Mathematica Publishing Inc., Winnipeg, Manitoba, Canada, 1975).

Key words: block-cutpoint tree; graph; tree; 2-connected.

If v is a vertex of degree at least three in a tree T and at least one branch at v is a path, then the subgraph of T consisting of the union of all such branch paths at v is called a leaf of T. There are infinitely many trees T with a given leaf structure (of two or more leaves), but certain of their parameters, such as the number of edges it is necessary to add to T to produce a 2-connected graph, are the same. Simple formulas are given for some of these parameters.

16155. Thomson, R., Fuller, E., **Crack morphology in relatively brittle crystals,** (Proc. Symp. on Fracture Mechanics of Ceramics, University Park, PA, July 11-13, 1973), Paper in *Fracture Mechanics of Ceramics,* R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., **1,** 283-295 (1973).

Key words: fracture; lattice trapping; slow-crack growth; stress corrosion.

From the viewpoint that cracks are atomically sharp, general outlines are given for some of the types of theories which should be developed for such cracks. The existence of atomic cleavage in a large class of materials is argued on the basis of the stability of a crack under spontaneous dislocation formation. A qualitative description of lattice trapping of a cleavage crack is given which correlates the effect to the atomic force laws. The determining factor for the observation of lattice trapping is the width of the cohesive region of the crack "core." Finally, a qualitative model of slow crack growth due to environmental effects is developed in terms of atomic dissolution at the crack tip.

16156. Wachtman, J. B., Jr., **Emerging priorities in ceramic engineering and science—Viewpoint of the scientist-engineer,** (Proc. Conf. on Emerging Priorities in Ceramic Engineering and Science, Alfred, NY, Nov. 4-6, 1974), Paper in *Ceramic Engineering and Science,* V. D. Frechette, L. D. Pye, and J. S. Reed, Eds., pp. 37-50 (Plenum Publishing Corp., New York, NY, 1974).

Key words: ceramics; educational priorities; energy; engineer-scientist; environmental quality; materials; minerals.

The role of the scientist-engineer regarding application of technology to national problems is discussed. The probable physical and social "environment" of the future scientist-engineer is assessed. Promising areas of ceramic science are discussed in broad terms. Some educational priorities are recommended.

16157. McNesby, J. R., **The role of standard reference materials in environmental measurements,** *Proc. National Conf. on Health, Environmental Effects, and Control Technology of Energy Use, Washington, DC, Feb. 9-11, 1976, Report No. 600/776-002,* pp. 58-60 (U.S. Environmental Protection Agency, Washington, DC, 1976).

Key words: air and water quality; energy; pollutants; standard reference materials.

The rationale for the importance of accurate as well as precise environmental measurement is presented. The role of Standard Reference Materials is to provide the analyst with NBS certified samples to facilitate his ability to make accurate measurement. Available energy related Standard Reference Materials are listed and those expected to be developed along with target dates are tabulated.

16158. Freeze, P. D., Thomas, D. B., **Studies of noble-metal thermocouple stability at high temperatures,** *NASA CR-135055,* 54 pages (National Aeronautics and Space Administration, Washington, DC, July 1976).

Key words: aging; calibration change; gradient; high temperature (700 to 2000 °C); iridium; iridium-rhodium alloy; noble-metal thermocouple; oxidation; platinum; platinum-rhodium alloy; preferential oxidation; temperature gradient; thermal gradient; thermocouple; thermoelectric stability.

This report describes two investigatory studies on performance characteristics of noble-metal thermocouples: (1) thermoelectric stability as affected by preferential oxidation of iridium in the system iridium-40 percent rhodium versus iridium, and (2) the effects of temperature gradients on the performance of the systems platinum-13 percent rhodium versus platinum and iridium-40 percent rhodium versus iridium, operating in air.

The stability investigation was carried out at three temperatures 1700, 1850, and 2000 °C—by comparing the output of the test thermocouple in air with the output of an identically constructed test-reference thermocouple in nitrogen. The results show that no calibration shift was observed producing a change in output greater than that corresponding to a 2.0 percent change in the test temperature.

The investigation of gradient effects was carried out by subjecting test thermocouples to both severe and mild gradients. For the platinum system, the operating temperature was 1500 °C with gradients of 1475 and 700 °C/cm; for the iridium system, 2000 °C with gradients of 700, 1500, and 1975 °C/cm. Exposure to temperature gradients was found to introduce significant changes in calibration for both systems.

In both investigations, the thermoelements were examined by means of electron-probe analysis and by metallographic methods to detect chemical and structural changes. Data and micrographs are presented.

16159. Meier, M. M., **Neutron standards at the National Bureau of Standards,** *Proc. Third Conf. on Application of Small Accelerators, North Texas State University, Denton, TX, Oct. 21-23, 1974,* CONF-741040-P1 **1,** 365-370 (Available from the National Technical Information Service, VA 22161, 1975).

Key words: associated particle technique; neutron detector; neutron flux monitor; neutron standards; neutrons; $T(p,n)^3He$ reaction.

The neutron standards program at NBS is discussed with emphasis on Van de Graaff contributions to the overall program. In particular, the characteristics of an associated particle apparatus, which serves as a primary standard for flux normalization at the three percent ac-

curacy level are presented. The "black" detector, a secondary standard, suitable as a flux monitor for linac applications and for dosimetry is characterized and its calibration with the associated particle technique is described. Future goals of the program are outlined and the Van de Graaff/associated particle system's future role in achieving them are discussed.

16160. Friauf, R. J., Young, K. F., Merz, W. J., **Properties of ionic crystals,** Paper 9f in *American Institute of Physics Handbook, Third Ed.*, pp. 9-74—9-127 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: crystals; ionic conductivity; ionic crystals; properties of ionic crystals.

16161. Frederikse, H. P. R., **Properties of semiconductors,** Paper 9e in *American Institute of Physics Handbook, Third Ed.*, pp. 9-56—9-74 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: band structure; properties of semiconductors; semiconductors; thermoelectric power.

16162. Frederikse, H. P. R., Slater, J. C., **Electronic properties of solids,** Paper 9c in *American Institute of Physics Handbook, Third Ed.*, pp. 9-26—9-38 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: distribution function; electronic properties of solids; energy band.

16163. Frederikse, H. P. R., **Structure, melting point, density, and energy gap of simple inorganic compounds,** Paper 9b in *American Institute of Physics Handbook, Third Ed.*, pp. 9-16—9-25 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: density; energy gap; inorganic compounds; melting point; structure.

16164. Wiese, W. L., Glennon, B. M., **Atomic transition probabilities,** Paper 7i in *American Institute of Physics Handbook, Third Ed.*, pp. 7-200—7-209 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: aluminum; argon; atomic transition probabilities; beryllium; boron; carbon; chlorine; helium; hydrogen; lithium; magnesium; nitrogen; oxygen potassium; sodium.

16165. Beaty, E. C., Persson, K. B., **Electrical conductions in gases,** Paper 5e in *American Institute of Physics Handbook, Third Ed.*, pp. 5-138—5-139 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: conduction; electrical conduction in gases; gases.

16166. Harris, F. K., **Electrical standards,** Paper 5c in *American Institute of Physics Handbook, Third Ed.*, pp. 5-107—5-119 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: absolute electrical standards; electrical standards; electrical units.

16167. Hilsenrath, J., **Thermodynamic properties of gases,** Paper 4h in *American Institute of Physics Handbook, Third Ed.*, pp. 4-162—4-204 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: air; argon; hydrogen; ionized gases; nitrogen; oxygen; thermodynamic properties.

16168. Furukawa, G. T., Douglas, T. B., **Heat capacities,** Paper 4e in *American Institute of Physics Handbook, Third Ed.*, pp. 4-105—4-118 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: entropy; heat capacity; molar heat capacity.

16169. Powell, R. L., Childs, G. E., **Thermal conductivity,** Paper 4g in *American Institute of Physics Handbook, Third Ed.*, pp. 4-142—4-162 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: conductivity; thermal conductivity.

16170. Greenspan, M., **Acoustic properties of liquids,** Paper 3e in *American Institute of Physics Handbook, Third Ed.*, pp. 3-86—3-98 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: acoustic properties of liquids; acoustics; Knester liquids; normal liquids; sound.

16171. McKinney, J. E., Lindsay, R., **Density and compressibility of liquids,** Paper 2l in *American Institute of Physics Handbook, Third Ed.*, pp. 2-148—2-187 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: compressibility; density; liquid compressibility; liquid density.

16172. Stegun, I. A., **SI units,** Paper 1b in *American Institute of Physics Handbook, Third Ed.*, pp. 1-8—1-13 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: metric; SI symbols; SI units.

16173. Stegun, I. A., Carter, C., **Mathematics bibliography,** Paper 1a in *American Institute of Physics Handbook, Third Ed.*, pp. 1-2—1-8 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: bibliography; indexes; mathematics bibliography.

16174. Frederikse, H. P. R., Hosler, W. R., Loeffler, N. L., **Testing and test analysis of MHD-materials,** *Proc. NSF-OCR Engineering Workshop on MHD-Materials, Cambridge, MA, Nov. 20-22, 1974*, pp. 138-149 (1974).

Key words: high temperatures; materials evaluation, MHD-materials; test procedures.

The problem of materials development for MHD-power generation is two-fold: The materials to be used in the channel, the combuster, the air-preheater, etc., must have the appropriate electrical and thermal characteristics and at the same time possess sufficient mechanical strength and chemical stability to withstand the very severe environmental conditions for periods of 1000-10,000 hours. This paper will discuss the test conditions in small and medium sized MHD-generators and the evaluation of the tested materials. The results of two short tests performed on 4 electrode materials in the UTSI-MHD-facility will be described and the conclusions drawn from these tests will be summarized.

16175. Albus, J. S., Evans, J. M., Johnsen, E. G., **A hierarchical concept for man-machine communication,** (Proc. 18th Annual Meeting of the Human Factors Society, Huntsville, AL, Oct. 15-17, 1974), Paper in *Benefits for Mankind*, E. L. Saenger and M. Kirkpatrick, III, Eds., pp. 506-509 (The Human Factors Society, Santa Monica, CA, Oct. 1974).

Key words: adaptive control; computer control; control theory; hierarchical control; man-machine communication and automation.

The problem of man controlling or programming a machine may be considered as a hierarchy of control functions, with each level of control calling up ordered sequences of operations at the next lower level, using appropriate sensory feedback for each level. Man may enter the control hierarchy at any level for direct control or for programming an automatic system for later playback. The computer carries out lower level control functions, thereby augmenting man's control capabilities.

The Cerebellar Model Articulation Controller (CMAC) is a computer based control system in which high-level task-oriented commands can be broken down into a series of elemental motor actuator signals. CMAC is a general purpose adaptive control concept which can be arranged in a hierarchical structure, such as that described

above, so as to facilitate the man-machine communication problem. For example, CMAC can solve the coordinate transformation problem so that commands can be given in terms of desired end point trajectories. Furthermore, CMAC can handle many feedback variables such as measurements of misalignment of parts, variable mass loading, irregularities in materials, and constraints imposed by an external environment.

16176. Lyons, J. W., **Requirements for fire safety of combustible materials in the United States,** *Proc. Int. Symp. on Fire Safety of Combustible Materials, Edinburgh, Scotland, Oct. 15-17, 1975*, **1**, 12-25 (1975).

Key words: fire codes; fire research; fire safety.

Fire safety of buildings and building furnishings in the United States is controlled by local codes and certain mandatory Federal requirements. The test methods and criteria used in codes generally are developed by technical committees of ASTM or NFPA. In a typical development these tests are first incorporated in the NFPA Life Safety Code, then in the four model building codes before finding their way into local codes. An alternative mechanism is inclusion in a mandatory Federal requirement as, for example, in the standards for housing insured by the Department of Housing and Urban Development, for nursing homes supported by the Department of Health, Education and Welfare, hospitals run by the Veterans Administration, or transportation vehicles regulated by the Department of Transportation. Test methods for these Federal agencies are developed by Federal research, often at the Center for Fire Research at the National Bureau of Standards.

The fire safety of consumer products falls under the purview of the Consumer Product Safety Commission. Test methods for CPSC are developed in two ways: by offerors in the private sector under provisions of the Consumer Product Safety Act of 1972, or by Federal research, for example at NBS.

There is great concern in the United States about the chaotic situation with regards to the validity of fire test methods. The focus on fire safety has in recent years shifted from fire endurance and compartmentation (which concepts apply to large buildings and are not helpful in single-family residences) to concern for the occupants in the room of origin and in single-family residences. This means we are now concerned with furnishings and interior finish materials. Tests for these items need considerable work. There is no one small test which permits one to assess the fire safety of a furnished enclosure. (The Federal Trade Commission has underscored this with a recent action against the advertising and promotional claims made based on results of small tests.) Current research efforts are directed to developing standardized full-scale fire tests for enclosures and improved correlations between these and small-scale economical tests. Active roles in this research are being played by the Center for Fire Research, Committee E-39 on Fire Hazard Standards in ASTM, and the Products Research Committee, established as part of a consent order between the FTC and a number of plastics manufacturers.

Fire research in the United States has received new impetus from the Federal Fire Prevention and Control Act of 1974. This Act established a new National Fire Prevention and Control Administration in the Department of Commerce and established anew the research on fire at the National Bureau of Standards. The Center for Fire Research at NBS has a new, broader assignment including its traditional research on fire phenomena and adding a major new responsibility for studies on the effects of fire on its victims (biological, physiological and psychological aspects).

The Fire Administration will be developing new equipment for fire fighting, detection, and suppression as well as helping to improve the efficiency and safety of fire fighting, helping with fire prevention and protection by performing code evaluation and assisting community planning and attacking public indifference through education. With this new emphasis and support at the Federal level, one hopes that United States fire losses will decrease in the future to come into line with fire losses of the other industrial nations of the world.

16177. Blanc, R. P., **Assisting network users with a network access machine,** *Proc. Annual Conf. of the Association for Computing Machinery, San Diego, CA, Nov. 11-13, 1974*, **1**, 74-84 (Association for Computing Machinery, New York, NY, 1974).

Key words: access procedures; computer networks; macros; minicomputers.

Accessing networks of heterogeneous computer systems can often be cumbersome due to differences in command languages and conventions. Approaches toward improving these conditions are identified and a specific solution—a "Network Access Machine"—is described in detail. The "Network Access Machine" is a minicomputer-based system that acts as a network access point for a user at his terminal and assists the user through the automatic execution of access procedures. This minicomputer facility allows the user to specify (or to have specified) his own network commands. The minicomputer expands these commands into command sequences executable on a specified network and host connected to that network. Further, system and network responses are analyzed to assure agreement with those anticipated for specific commands. Conditional and parameterized expansions allow the use of the same commands on different host computers and different networks.

16178. Breden, L. H., Meisters, M., **The effect of sample orientation in the smoke density chamber,** *J. Fire Flammability* **7**, 234-247 (Apr. 1976).

Key words: fire performance; horizontal and vertical smoke measurements; smoke; smoke density chamber; smoke suppressants.

Smoke measurements were compared for various materials in the vertical and horizontal positions. There appeared a significant difference for thermoplastic materials because of the melting away from the incident heat flux in the vertical position. The horizontal mode in addition allows one to relate the chemistry of polymeric materials to the amount of smoke production. Finally, smoke measurements are made of products containing various amounts of smoke suppressants.

16179. Bright, R. G., **Early warning fire detection,** *Proc. Fire Protection in Interior Design, Cleveland, OH, Apr. 10-11, 1975*, pp. 170-184 (1975).

Key words: atriums; fire detection; flame detectors; heat detectors; hospitals; hotels; maintenance; nursing homes; reliability; schools; smoke detectors.

A description of the specialized signatures of fire conditions along with a description of the various available fire detectors are presented. Some special problems of fire detectors such as reliability and maintenance are discussed. The paper closes with a discussion of specialized applications of fire detection to open plan office buildings, atriums, schools, buildings with smoke control systems and the use of detectors in corridors.

16180. Pease, R. L., Galloway, K. F., Stehlin, R. A., **Radiation damage to integrated injection logic cells,** (Proc. IEEE Nuclear and Space Radiation Effects Conf., Eureka, CA, July 14-17, 1975), *IEEE Trans. Nucl. Sci.* **NS-22**, No. 6, 2600-2604 (Dec. 1975).

Key words: digital bipolar circuits; integrated injection logic; radiation damage; radiation effects.

The effects of neutron and total dose gamma irradiations on the electrical characteristics of an integrated injection logic (I^2L) cell and an I^2L multiple inverter circuit were investigated. These units were designed and fabricated to obtain circuit development information

and did not have radiation hardness as a goal. The following parameters of the test structures were measured as a function of total dose and neutron fluence: the dc common-base current gain of the lateral *pnp* transistor; the dc common-emitter current gain of the vertical *npn* transistor; the forward current-voltage characteristics of the injector-substrate junction, and the propagation delay versus power dissipation per gate for the multiple inverter circuit. The limitations of the present test structures in a radiation environment and possible hardening techniques are discussed.

16181. Maki, A. G., Freund, S. M., **Laser Stark measurements on OCS including the observation of zero-field-forbidden $\Delta J = 0, \pm 2$ transitions,** *J. Mol. Spectrosc.* **62,** 90-98 (1976).

Key words: carbonyl sulfide; dipole moments; infrared; lasers; spectra; spectroscopy; Stark effect.

Laser Stark measurements have been made on the $02^{0}0$-$00^{0}0$ and $03^{1}0$-$01^{1}0$ vibrational transitions of $^{16}O^{12}C^{32}S$, $^{16}O^{12}C^{34}S$, and $^{18}O^{12}C^{32}S$, and on the $03^{1}0$-$01^{1}0$ transition of $^{16}O^{13}C^{32}S$, using a CO_2 laser. In addition to providing dipole moment information for excited vibrational states, these measurements give vibrational band centers accurate to several megahertz. To aid in optical pumping experiments, several near coincidences between CO_2 laser transitions and OCS absorption lines are discussed. Electric-field-allowed $\Delta J = 0$ transitions are observed for the $2v_2$ band of $^{16}O^{12}C^{32}S$ and $^{16}O^{12}C^{34}S$, as well as $\Delta J = 2$ transitions for the same band of $^{18}O^{12}C^{32}S$.

16182. Caswell, R. S., Coyne, J. J., **Neutron energy deposition spectra studies,** (Proc. 4th Symp. on Microdosimetry, Verbania Pallanza, Italy, Sept. 24-28, 1973), Paper in *Fourth Symposium on Microdosimetry,* J. Booz, H. G. Ebert, R. Eickel, and A. Waker, Eds., EUR 5122 d-e-f, pp. 967-979 (Commission of the European Communities, Luxembourgh, Mar. 1974).

Key words: energy deposition spectra; microdosimetry; neutron interactions with tissue; neutrons; radiation quality; secondary particle spectra; theoretical dosimetry.

Secondary particles (p, α, C, N, etc.) are generated when neutrons interact with tissue. We are concerned with three spectra of these secondary particles: (1) the "initial" spectra which come from neutron cross section information; (2) the "slowing-down spectra" which are obtained from the initial spectra and secondary particle stopping power data, and (3) the "energy deposition spectra"—the spectra of energy depositions by the secondary particles in small tissue volumes, which depend upon both the previous spectra, the geometrical properties of the volume, and upon stopping power and range information. We have calculated all of these spectra for a number of energies of monoenergetic neutrons between 60 keV and 14 MeV using analytic methods previously described. Examples will be given of the variation of the spectra and of certain spectral averages such as the frequency and dose averages of lineal energy ($\bar{y}_f$,$\bar{y}_D$) as a function of neutron energy. Experimental information for comparison exists for spectra of type (3), and we understand measurements of spectra of type (1) are underway.

16183. Gross, D., **The measurement and correlation of fire growth in a room,** *Proc. Symp. on Full-Scale Fire Tests, Lancaster, PA, Nov. 11-12, 1974,* pp. 77-87 (Research and Development Center, Lancaster, PA, 1976).

Key words: buildings; fire growth; flame spread; heat release; interior finish; reduced scale modeling; room corner tests; smoke.

Evaluation of fire growth in a room requires characterization of the source fire, defining a measure of full fire involvement, and correlation in terms of small-scale laboratory tests. A series of 20 room-corner tests was performed using a wood-crib ignition source and selected combinations of interior-finish materials on wall and ceiling surfaces. The upper room-gas temperature was taken as a measure of fire-growth level and potential involvement of all combustible contents. Comparisons are presented between results of the full-scale tests and available laboratory tests on the interior-finish materials. Supplementary approaches involving analytical and reduced-scale modeling are also discussed.

16184. Hust, J. G., Schramm, R. E., **Density and crystallinity measurements of liquid and solid *n*-undecane, *n*-tridecane, and *o*-xylene from 200 to 350K,** *J. Chem. Eng. Data,* **21,** No. 1, 7-11 (1976).

Key words: cryogenics; crystallinity; density; expansion; paraffins.

Densities of solid and liquid *n*-undecane, *n*-tridecane, and *o*-xylene are reported for temperatures from 200 to 350K. Density increases upon freezing by 13, 13, and 12 percent, respectively, for these hydrocarbons. The data are presented graphically and are also represented by equations to within the scatter of the data. The uncertainties of the data are 0.2 percent for the liquid and 1 percent for the solid state. X-ray examinations revealed that these materials have complex crystalline structures when frozen. Near 200K the main crystal structure is orthorhombic, but several phase transformations occur for each of these materials between 200K and the melting point.

16185. Richmond, J. C., **Courtroom of the future. Court related use of videotape recordings,** (Proc. Seminar on Civil Trial Advocacy, University of Kentucky, Lexington, KY, Jan. 23-24, 1976), Paper in *Report of Seminar on Civil Trial Advocacy,* pp. 43-45 (Office of Continuing Legal Education, University of Kentucky, Lexington, KY, July 1976).

Key words: closed circuit television; court proceedings; court security; trial proceedings; videotape recording.

The presentation consisted of showing the videotape "Courtroom of the Future," plus showing slides giving more detail about certain features of the Courtroom of the Future at the McGeorge School of Law in Sacramento, California. The equipment for recording trial proceedings on video, and precautions for court security were emphasized.

16186. Richmond, J. C., **The courtroom of the future,** (Proc. 8th Annual Crime Countermeasures Conf., Lexington, KY, Apr. 15-19, 1974), Paper in *Proc. 1974 Carnahan and Int. Crime Countermeasures Conf., UKY BU* **105,** 152 (Aug. 1974).

Key words: closed circuit television; court proceedings; court security; trial proceedings; videotape recording.

The presentation consisted of showing the videotape "Courtroom of the Future," plus showing slides giving more detail about certain features of the Courtroom of the Future at the McGeorge School of Law in Sacramento, California. The equipment for recording trial proceedings on video, and precautions for court security were emphasized.

16187. Bright, R. G., **Regulations and standards concerning fire detection systems in the United States,** *Proc. 7th Int. Seminar on Problems in Automatic Fire Detection, Aachen, Germany, Mar. 5-6, 1975,* pp. 47-60 (Institut für Elektrische Nachrichtentechnik, Aachen, Germany, 1975).

Key words: fire detection; regulations; smoke detectors; United States standards.

Historically, fire detection systems for the protection of people and property from fire have not enjoyed wide usage in the U.S. With respect to property protection the emphasis has been on the use of automatic sprinkler systems as opposed to automatic fire detection systems. This trend is likely to continue for the foreseeable future. It is in protecting people from fire that automatic fire detection is receiving ever increasing attention.

The U.S. loses an inordinate number of people each year in fires. As most of this loss-of-life takes place in the family life unit, more and more of the U.S. regulatory agencies are requiring the inclusion of automatic fire detection devices, primarily smoke detectors, in all new family living units. This includes apartments, single-family dwellings, and mobile homes.

The paper describes the trends evident in these regulations. The paper also describes the type of smoke detection devices required by these regulations, some of the shortcomings evident in the presently available smoke detectors, and the status of testing and approval standards used to judge the suitability of smoke detectors for life safety.

16188. Unassigned.

16189. Clifton, J. R., **Protection of reinforcing bars with organic coatings,** *Mater. Perform.* **15,** No. 5, 14-17 (May 1976).

Key words: bridge decks; chloride ions; corrosion; deicing salts; epoxy coatings; organic coatings; steel reinforcing bars.

Results of a program aimed at identifying organic coatings suitable for steel reinforcing bars in concrete are given. Resistances of candidate coatings to abrasion, solutions of calcium chloride, hydroxide, sulfate, and fresh cement paste, and surface preparation of steel, resistance of coated bars to electrical currents, and concrete-to-coating bonding are discussed. Tests were made on liquid and powdered epoxy, polyvinylchloride liquid, polypropylene powder, phenolic nitrile liquid, and zinc rich liquid coatings.

16190. Treado, M. J., **Development of reports and guidelines for law enforcement communications equipment,** (Proc. 8th Annual Crime Countermeasures Conf., Lexington, KY, Apr. 16-19, 1974). Paper in *Proc. 1974 Carnahan and Int. Crime Countermeasures Conf., UKY BU* **105,** 102-112 (Aug. 1974).

Key words: communications; digital communications; guideline; law enforcement equipment report, Law Enforcement Standards Laboratory; mobile digital equipment; National Institute of Law Enforcement and Criminal Justice.

The Law Enforcement Standards Laboratory (LESL) was established by NBS for the National Institute of Law Enforcement and Criminal Justice (NILECJ) primarily to develop performance standards to assist law enforcement agencies in their equipment selection and procurement process. In addition to performance standards, LESL also is developing equipment reports, guidelines and glossaries for use by the law enforcement community. This paper uses a typical study effort, in this case one on mobile digital communications, to illustrate the development of a law enforcement equipment report.

16191. Schramm, R. E., Reed, R. P., **Stacking fault energies of fcc Fe-Ni alloys by x-ray diffraction line profile analysis,** *Metall. Trans. A* **7A,** No. 3, 359-363 (Mar. 1976).

Key words: invar; iron alloys; nickel alloys; stacking fault energy; x-ray diffraction.

The stacking fault energies of the fcc alloy series Fe-28 Ni to pure Ni were investigated using x-ray diffraction line profile analysis. A minimum stacking fault energy of about 70 mJ/m^2 occurs at the approximate composition of Fe-40 pct Ni. From this point, the lower nickel alloys rapidly increase to a very high stacking fault energy, estimated to be 200 mJ/m^2, while the energies of the high Ni alloys rise linearly to the Ni value of 214 mJ/m^2. Anomalous reductions of the lattice parameter after cold work were found for the low nickel alloys; this was interpreted as evidence for Fe_3Ni ordering and corrections to the stacking fault energy were made.

16192. McNeil, J. R., Collins, G. J., Persson, K. B., Franzen, D. L., **Ultraviolet laser action from Cu II in the 2500-Å region,** *Appl. Phys. Lett.* **28,** No. 4, 207-209 (Feb. 15, 1976).

Key words: Cu II spectrum; ultraviolet laser, 250.0 nm.

We have obtained cw laser action from Cu II at 2486, 2506, 2591, and 2599 Å by exciting a neon discharge in a copper hollow cathode. We have observed 7-mW cw output power just above threshold and the output appears to saturate at 210 mW under quasi-cw operation. The four ultraviolet laser lines observed originate from the $3d^9 5s(^3D)$ term of Cu II. The quantum efficiency of the 2500-Å laser transitions approaches 25 percent. Each of the four Cu II laser transitions has been employed in the past by spectroscopists as a secondary wavelength standard in the ultraviolet.

16193. Andrews, J. R., Lawton, R. A., **Electrically strobed optical waveform sampling oscilloscope,** *Rev. Sci. Instrum.* **47,** No. 3, 311-313 (Mar. 1976).

Key words: laser; optical pulse; oscilloscope; photoconductor; pulse measurements; sampling.

A new instrument for measuring optical waveforms is described. It is an optical sampling oscilloscope employing a GaAs photoconductive sampling gate and an electrical sampling strobe. The basic theory of operation is derived. A 100-psec rise-time rudimentary prototype has been built and results of measurements of a GaAs laser diode pulse are presented.

16194. Tobler, R. L., Read, D. T., **Fatigue resistance of a uniaxial S-glass/epoxy composite at room and liquid helium temperatures,** *J. Compos. Mater.* **10,** 32-43 (Jan. 1976).

Key words: cryogenics; fatigue; fiber composites; liquid helium; low temperature tests; mechanical properties.

Tension-tension axial fatigue tests of a uniaxial glass filament-reinforced epoxy were conducted at 295 K and 4 K. The fatigue life was found to be an order of magnitude greater at 4 K than at 295 K. These results are believed to be the first 4 K fatigue data reported for a composite material.

16195. Dalke, J. L., **Metric system versus anthropomorphic units—A bicentennial coup?,** *Am. Metric J.* **4,** No. 3, 121-123 (1976).

Key words: anthropomorphic units; bicentennial; history of measurement; metric conversion; metric roll call; metrology; Public Law 93-380; Public Law 94-168.

The U.S.A. declared its independence in 1776. The Bicentennial Anniversary of this occasion ironically also is the beginning of a stronger commitment to discard our cumbersome customary English measurement system, an action that is already well underway in English speaking countries. The English system now persists most strongly in the U.S., yet in addition to its inconsistencies it is to our economic disadvantage to continue the use. Public Law 94-168, the Metric Conversion Act of 1975, which became effective December 23, 1975, provides a mechanism for promoting the metric system in the U.S. Thus, in 1976, the Bicentennial year, we begin to push more sharply for independence from a measurement system that is becoming obsolete. A synopsis is given of the development of anthropomorphic measurements and an overview of metric (SI) usage in the U.S., including a metric "roll call" of industry.

16196. Clark, A. F., Haynes, W. M., Deason, V. A., Trapani, R. J., **Low temperature thermal expansion of barium ferrite,** *Cryogenics* **16,** No. 3, 267-270 (May 1976).

Key words: barium ferrite; low temperature; thermal expansion.

The linear thermal expansion of polycrystalline barium ferrite, $BaFe_{12}O_{19}$, was measured from 76 to 293 K both parallel and perpendicular to the magnetization direction. An anisotropy of about 15-20

percent was observed. The results match well the available data above room temperature and have also been extrapolated to 0 K.

16197. Richmond, J. C., **Criteria for evaluating image quality of night vision devices,** (Proc. 8th Annual Crime Countermeasures Conf., Lexington, KY, Apr. 16-19, 1974), Paper in *Proc. 1974 Carnahan and Int. Crime Countermeasures Conf., UKY BU* **105,** 83-94 (Aug. 1974).

Key words: acutance; contrast transfer function; edge gradient; image quality; light equivalent background; light induced background; limit resolution; line spread function; optical transfer function; point spread function.

The National Bureau of Standards is developing Standards for image intensifier night vision devices for use in law enforcement, under a project managed by the Law Enforcement Standards Laboratory of NBS, which is sponsored by the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Agency of the Department of Justice. The quality of the image produced by such a device is an important measure of its utility, and image quality criteria are an important part of such a Standard. Many variables contribute to image quality, not all of which have been identified, or can be measured. This paper is a literature survey of criteria and techniques that have been used to evaluate the quality of imaging systems, with some discussion of their application to image intensifier night vision devices.

16198. Rockett, J. A., **Who will design fire protection of the future,** *Society of Fire Protection Engineers, Technical Report 75-5,* pp. 1-5 (Society of Fire Protection Engineers, Boston, MA, 1975).

Key words: fire protection; future trends; professional qualifications.

The professional cross section of fire protection engineers of a decade from now is discussed. Present trends in the field are projected and it is suggested that a much broader and richer set of professional backgrounds will be found.

16199. Stokesberry, D. P., Hasegawa, S., **Automatic digital microwave hygrometer, model II,** *Rev. Sci. Instrum.* **47,** No. 5, 556-558 (May 1976).

Key words: digital microwave hygrometer; hygrometer, digital microwave; microwave, digital, hygrometer.

A "ruggedized" microwave hygrometer which requires no moving parts in the basic measurement method is described. It is designed to measure atmospheric humidity over the vapor pressure range 3-7400 pascals (Pa) (0.03-74 millibar).

16200. McDonald, D. G., Johnson, E. G., Harris, R. E., **Modeling Josephson junctions,** *Phys. Rev. B* **13,** No. 3, 1028-1031 (Feb. 1, 1976).

Key words: cryogenics; electronic tunneling; Josephson effect; superconductivity.

The current-voltage characteristic of a current-biased junction is calculated using the Werthamer theory. In contrast with the voltage-biased model large zero-frequency currents exist at 0 K at all bias voltages below the energy gap and the Riedel peak is directly displayed. The effect of capacitance on the *I-V* curve is described and the form of the subharmonic energy-gap structure is calculated using the Mattis-Bardeen model for the superconducting electrodes.

16201. Rockar, E. M., Forman, R. A., **Fe^{4+} ($3d^4$) optical absorption in oxidized $SrTiO_3$,** *Phys. Status Solidi A Short Notes* **33,** K91-K95 (1976).

Key words: charge transfer, color centers; crystal field; d^4 ions; EPR; iron 4+; optical absorption; perovskite; strontium titanate; transition metal; zero phonon line.

The optical absorption spectrum of oxidized, iron doped $SrTiO_3$ at 10 K exhibits a sharp line at 772.5 nm (12,945 cm^{-1}) with side bands at $\Delta\nu_1 = 116$ cm^{-1}, $\Delta\nu_2 = 168$ cm^{-1}, and $\Delta\nu_3 = 315$ cm^{-1}. After moderate reduction in flowing H_2 at 900 °C this line and its vibronics disappear. The spectrum is attributed to the $^5E_g \rightarrow {}^3T_{1g}$ transition of Fe^{4+} ($3d^4$).

16202. Howard, C. J., Evenson, K. M., **Rate constants for the reactions of OH with ethane and some halogen substituted ethanes at 296 K,** *J. Chem. Phys.* **64,** No. 11, 4303-4306 (June 1, 1976).

Key words: fluorocarbons; hydroxyl radical; reaction rate constants.

Absolute rate constants for the reactions of OH radicals with C_2H_6 and twelve fluorine, chlorine, and bromine substituted ethane compounds are reported. The measurements are made at 296 K and pressures ranging from 100 to 1000 Pa (0.7-7 torr) using a discharge-flow system and laser magnetic resonance detection of OH. The results are similar to those of an earlier work on a series of methane compounds and indicate that the reaction mechanism is the abstraction of an H atom. Thus, completely halogenated molecules are relatively inert. The hydrogen containing molecules react with rate constants ranging from about 3 to 400×10^{-15} cm^3 $molecule^{-1} \cdot sec^{-1}$.

16203. Ogburn, F., **Electrodeposition and government laboratories,** *Plating Surf. Finish.* **63,** No. 7, 24-29 (July 1976).

Key words: Blum, William; electrodeposition; government laboratories; plating.

Government laboratories have made numerous contributions to the science and technology of electrodeposition in the form of commercial instruments and process as well as engineering data and scientific information. These laboratories and their more significant contributions are briefly reviewed as seen through the eyes of one Government scientist.

16204. Birky, M. M., **Philosophy of testing for assessment of toxicological aspects of fire exposure,** *J. Combust. Toxicol.* **3,** 5-23 (Feb. 1976).

Key words: bioassay; combustion products; fire; hazard assessment; toxicity.

Detailed investigation of fire fatalities and autopsies of fire victims indicate the interaction of carbon monoxide, pulmonary injury, alcohol and cardiovascular disease in fire fatalities that are attributed to smoke inhalation. Laboratory assessment of the toxicity hazard of combustion products has relied predominantly on chemical analysis for a few selected toxic gaseous species such as carbon monoxide. While the clinical data suggest that carbon monoxide has been the predominant toxicant in past fatalities, the advent of new synthetic materials that contain fire retardants or are inherently more fire resistive have the potential of contributing other unknown toxicants. In addition, the particulate phase (smoke) may play a major role in inhalation toxicity that cannot be assessed by means of chemical analyses. In the past the toxicity of some new fire retardants has been screened using feeding experiments. While this is an important first step, experiments to determine the inhalation toxicity of the thermal degradation products, of the fire retardants and of polymers incorporating fire retardants must also be made to assess the acceptability of such materials.

This paper proposes that a multi-disciplinary program, including toxicological, chemical and combustion expertise, is required to assess the toxicological effects of combustion products. The product mixture is so complex that a toxicity assessment will require animal exposures combined with analysis of selected gases and correlation with biomedical information.

16205. Rosenstock, H. M., **The measurement of ionization and**

appearance potentials, *Int. J. Mass Spectrom. Ion Physics* **20,** 139-190 (1976).

Key words: appearance potential; gaseous positive ions; heat of formation; ionization potential; measurement.

Measurement techniques and methods of data interpretation leading to ionization potentials, appearance potentials and heats of formation of gaseous positive ions are summarized and critically discussed. Special attention is paid to defining the accuracies, problems and limitations of the techniques and interpretations. References have been selected and cited which discuss these matters in more detail.

16206. Hust, J. G., **Thermal conductivity standard reference materials, Progress Report,** (Proc. XIII Int. Conf. on Thermal Conductivity, Lake of the Ozarks, MO, Nov. 5-7, 1973), Paper in *Advances in Thermal Conductivity,* R. L. Reisbig and H. J. Sauer, Jr., Eds., pp. 22-24 (1974).

Key words: austenitic steel; cryogenics; electrical resistivity; electrolytic iron; Lorenz ratio; thermal conductivity.

Current and past research in the area of standard reference materials is described. New characterization data for SRM's 734 and 735 (thermal conductivity standard reference materials) are discussed. Low temperature thermal conductivity data for sintered tungsten are included in anticipation of establishing this material as a thermal conductivity standard reference material. Present indications are that SRM 734 (electrolytic iron) may be extended to temperatures as high as 800 °C and SRM 735 (austenitic stainless steel) may be extended to 100 °C as thermal conductivity standard reference materials. It appears that tungsten may be used to temperatures as high as 2700 °C.

16207. Daney, D. E., **Turbulent natural convection of liquid deuterium, hydrogen and nitrogen within enclosed vessels,** *Int. J. Heat Mass Transfer* **19,** No. 4, 431-441 (Apr. 1976).

Key words: cryogenics; heat transfer; hemisphere; horizontal cylinder; liquid deuterium, liquid hydrogen, liquid nitrogen; natural convection; sphere; vertical cylinder.

Quasi-steady natural convection of liquid deuterium, hydrogen, and nitrogen within a sphere, hemisphere, horizontal cylinder, and vertical cylinder has been studied experimentally for the case of a nearly uniform wall temperature. A single expression relating the Nusselt and Rayleigh numbers,

$$Nu = 0{\cdot}104\, Ra^{0.352},$$

fits the deuterium and nitrogen data over the range $7 \times 10^8 < Ra < 6 \times 10^{11}$, while the hydrogen Nusselt numbers are 8 percent lower. The temperature field within the vessels is virtually free of horizontal temperature gradients. A single dimensionless temperature profile characterizes the vertical temperature distribution for each vessel shape, with the profiles for the sphere, hemisphere, and horizontal cylinder being nearly identical.

16208. Siegwarth, J. D., **A high conductance helium temperature heat switch,** *Cryogenics* **16,** No. 2, 73-76 (Feb. 1976).

Key words: gold plating; heat switch; He temperature; high conductivity.

Metallic contact heat switches with high thermal conductances have been designed and tested in the 4 to 15 K temperature range. Both gold plating and solid silver were used for the contact surfaces. Switch conductances greater than 1W K^{-1} at 15 K were achieved for a switch closed at this temperature with a force of 54 kg. The conductance is proportional to temperature, and varies approximately as the 2/3 power of the closing force.

16209. Weiss, A. W., **Transition probabilities for ionized atoms,** (Proc. 4th Int. Conf. on Beam-Foil Spectroscopy, Gatlinburg, TN, Sept. 15-19, 1975), Paper in *Beam-Foil Spectroscopy,* I. A. Sellin and D. J. Pegg, Eds., **1,** 51-68 (Plenum Publishing Corp., New York, NY, 1976).

Key words: ions; oscillator strengths; quantum mechanics; spectroscopy; transition probabilities; wave functions.

Several aspects of the line strength problem for ionized atomic systems are discussed. Level crossings, which arise from the restructuring of the ionic spectrum, occur frequently in the medium stages of ionization and can produce severe irregularities in the f-value behavior along an isoelectronic sequence. Calculations on several such examples are described. For very highly ionized species relativistic effects must be taken into account, and the hydrogen-like line strengths are discussed as a prototype of orbital relativistic effects. For many-electron systems the major relativistic effect is intermediate coupling, and multi-configuration calculations including the dominant Pauli approximation corrections have been done on a number of ions. Results are presented for the beryllium and boron isoelectronic sequences.

16210. Larsen, E. B., Andrews, J. R., **Using fiber optics in a broadband, sensitive, isotropic antenna—15 kHz to 150 MHz,** *Proc. IEEE Int. Symp. on Electromagnetic Compatibility, Washington, DC, July 13-15, 1976,* pp. 385-389 (Institute of Electrical & Electronics Engineers, Inc., New York, NY, 1976).

Key words: broadband antenna; electromagnetic compatibility; fiber optics; field strength measurement; isolated EMC antenna; sensitive isotropic probe.

A broadband, active, isotropic receiving antenna was developed at NBS for the frequency range 15 kHz to 150 MHz. It was designed for use with a conventional receiver to measure weak, near-zone electric fields of unknown polarization, such as leakage emanations from electronic equipment placed within a shielded enclosure. The antenna system consists of three mutually-orthogonal active dipoles, each 31 cm long by 3 cm diameter. The entire frequency range of each of the three field components is amplified and used to modulate a high-speed light emitting diode (LED) located inside the dipole. The modulated infrared (IR) signals are guided through glass fibers 10 meters long which connect the "isolated" dipoles to avalanche photodiodes at the far end of the fiber guides. These photodetectors recover the RF modulation from the IR carrier for input to the receiver. The fiber-optic antenna system described in this paper has high sensitivity (down to 10 μV/m) and fast response time (RF modulations up to 150 MHz). The readout indication at each receiver frequency is proportional to the Hermitian magnitude of E, which is the root-sum-square value of three orthogonal E field components at the measurement point.

16211. Torchia, D. A., Lyerla, J. R., Jr., Quattrone, A. J., **A ^{13}C magnetic resonance study of the helix and coil states of the collagen peptide αl-CB2,** (Proc. Rehovot Symp. on Poly(Amino Acids), Polypeptides, and Proteins and Their Biological Implications, Israel, May 1-8, 1974), Paper in *Peptides, Polypeptides and Proteins,* E. R. Blout, F. A. Bovey, M. Goodman, and N. Lotan, Eds., pp. 436-448 (John Wiley & Sons, New York, NY, 1974).

Key words: collagen; conformation; correlation times; cyanogen bromide peptides; polypeptides; relaxation times; rotational diffusion; ^{13}C magnetic resonance.

Carbon-13 chemical shifts, spin-lattice (T_1) and spin-spin (T_2) relaxation times and ^{13}C-^{1}H nuclear Overhauser enhancements (NOE) have been determined for the coil and triple helical states of the αl-CB2 fragment of rat skin collagen. Assignment of all aliphatic resonances of this 36 residue peptide in the random coil state (30°) has been achieved with the aid of model polypeptides containing pyrrolidine residues. The T_1 measurements show that the interior backbone carbons of the coil are characterized by effective rotational correlation times (τ_{eff}) of *ca.* 0.45 nsec. while sidechain and near ter-

minal backbone τ_{eff} values are 2-5 times shorter. These results along with the narrow natural linewidths (3-5 Hz) and maximum NOE values (3.0) demonstrate the high degree of backbone segmental motion and sidechain mobility in the unordered state of the peptide. By contrast, the broad lines (50-80 Hz) and low NOE values (1.3) for the α-carbons in the helical state (2°) suggest much slower motion. These results together with the T_1 values (0.025-0.040 sec) are consistent with a model in which the motion of the ordered state of αl-CB2 is described by rotational diffusion of an axially symmetric rigid ellipsoid having dimensions approximating those expected for a collagen-type helix of 36 residues.

16212. Sweeney, W. T., **Dental research at the National Bureau of Standards 1919-1969,** *Br. Dent. J.* **127,** 289-290 (Sept. 16, 1969).

Key words: amalgam; composite materials; dental gold alloys; dental research; panoramic x ray; silicate cement; turbine handpiece.

The dental research program started at NBS in 1919 has continued as a joint effort with the cooperation of the American Dental Association, the National Institute of Dental Research, the U.S. Army, the U.S. Air Force, and the Veterans Administration. The staff of about 35 is made up of Research Associates, Guest Workers, and employees of the National Bureau of Standards. Approximately 500 papers have been published on dental materials, including amalgam, gold alloys, cements, denture base materials, and on research related to natural tooth structure. Materials and instruments, including the high speed turbine handpiece and the panoramic x-ray machine developed at NBS, have made major contributions to the practice of dentistry.

16213. Coriell, S. R., Sekerka, R. F., **The effect of the anisotropy of surface tension and interface kinetics on morphological stability,** *J. Cryst. Growth* **34,** No. 2, 157-163 (July 1976).

Key words: alloys; anisotropy; interface kinetics; solidification; stability; surface tension.

The theory of the morphological stability of a planar interface during solidification of a binary alloy has been modified to account for an anisotropic departure from local equilibrium (anisotropic interface kinetics) at the solid-liquid interface. The temperature for local equilibrium is calculated from the Gibbs-Thomson equation for anisotropic surface tension. Departure from local equilibrium is characterized by taking the interface velocity to be a function of thermal undercooling, concentration, orientation, and curvature. A perturbation analysis leads to the conclusion that an isotropic departure from local equilibrium causes a modification of the capillary terms and liquidus slope as they enter the expression for the time evolution of perturbations; in addition, perturbation growth rate is retarded. Allowance for anisotropy of surface tension causes the capillary terms to depend on direction. Anisotropic interface kinetics leads to the additional important effect that sinusoidal perturbations are translated parallel to the unperturbed interface as they change in amplitude. The peaks of such sinusoidal perturbations will therefore grow at an angle to the normal of the unperturbed interface. This effect is believed to be an underlying cause for the existence of preferred directions for cellular and dendritic growth.

16214. Truhlar, D. G., **Interpretation of ortho-para hydrogen conversion,** *J. Chem. Phys.* **65,** No. 3, 1008-1010 (Aug. 1, 1976).

Key words: chemical reactions; collision theory; hydrogen atoms; hydrogen molecules; indistinguishable particles; nuclear spin; rate coefficients; transition-state theory.

The interpretation of statistics of the nuclear spin states in the ortho-para hydrogen conversion by hydrogen atoms is considered. It is shown that the observable rate coefficient (which is the sum of the forward and reverse rate coefficients for Para→ortho conversion) equals the distinguishable-atom rate coefficient in the classical limit. In addition to spin-1/2 nuclei, we also consider spin-1 nuclei and spin-0 nuclei.

16215. Persensky, J. J., **Human factors in product safety research,** *ASHRAE Trans.* **81,** Part 2, 434-440 (Dec. 1975).

Key words: appliances; behavioral science; human factors; product safety; safety; safety research.

In 1955, the National Bureau of Standards (NBS) provided the basic human performance and reaction data necessary for the establishment of an appliance safety standard under the Refrigerator Safety Act of 1956. Between that time and the early 1970's, human factors aspects of product safety research have received little attention. Recently, however, the enactment of the Consumer Product Safety Act has provided a new impetus to product safety research. Members of ASHRAE should be particularly interested in the results of such research since a number of their products rank among the top products on the Consumer Product Safety Commission's (CPSC) list of hazardous products. Included are: space heaters, furnaces and water heaters. Unfortunately, almost no human factors data are available to serve the needs of safety motivated, product improvements. NBS has been working with CPSC since late 1973 and has established a program including human factors research to support the development of product safety standards. NBS will obtain human performance and reaction data related to the use of products in a naturalistic situation. In order to accomplish this, novel approaches to the collection of data are being developed.

This presentation describes some of the research. A generalized methodology involving critical incident and naturalistic observation techniques is presented. The presentation closes with illustrations of some of the problems associated with behavioral research.

16216. McBee, C. L., Kruger, J., **Events leading to the initiation of the pitting of iron,** (Proc. Int. Conf. on Localized Corrosion, Williamsburg, VA, Dec. 6-10, 1971), Paper in *Localized Corrosion*, R. Staehle, B. F. Brown, J. Kruger, and A. Agrawal, Eds., NACE-3, 252-260 (National Association of Corrosion Engineers, Houston, TX, 1974).

Key words: ellipsometry; iron; kinetics; optical constants; passive; pitting; spectroscopy.

Ellipsometric spectroscopy was used to analyze the changes in the passive film on Fe caused by chloride. The changes studied were the optical variations that take place in the film during the time period between introduction of chloride ions to the solution after passive film growth and the time just prior to breakdown.

It was found that the visible spectrum of the passive film on Fe at potentials above the critical pitting potential, E_p, is affected at only a few wavelengths when chloride is introduced into the solution in which the film is formed. At potentials below the critical pitting potential, the introduction of chloride produces optical changes at all wavelengths in the visible spectrum and can be interpreted as causing film thickening. Annealing the passive film grown above the critical pitting potential at 75 °C prior to the introduction of chloride produces the same results as that for films at potentials below E_p. Removal of chloride from the solution just prior to breakdown of the film results in a return of the optical parameters to the values found for a passive film.

The time to breakdown in chloride increases with increasing film thickness. The time for recovery of the passive state decreases with increasing film thickness. The overall concentration of chloride introduced in a film decreases with thickness for films grown at potentials above the critical pitting potential.

The results of this study point to a mechanism for passive film breakdown on Fe that requires a penetration of chloride via lattice defects.

16217. Scheps, R., Gallagher, A., **Teratomic recombination in alkali metal-noble gas vapors,** *J. Chem. Phys.* **65,** No. 3, 859-871 (Aug. 1, 1976).

Key words: alkali metal-noble gas vapors; gas vapors; metal-noble gas vapors; vapors, gas.

The teratomic recombination rates for the reaction $M^* + 2X \rightarrow MX^*(A^2\Pi) + X$ have been studied for Rb-Xe, Na-Ar, Ke, Xe, and Li-Ar, Kr, Xe. This analysis employs data and molecular potential determinations from earlier measurements where free alkali M was optically excited to M^* in the presence of noble gas X and the $MX^*(A^2\Pi) \rightarrow MX(X^2\Sigma)$ fluorescence resulting from teratomic recombination was measured. Collisional processes compete with radiative decay, so that in the low [X] limit where dissociation collisions are negligible the ratio of bound molecular to atomic photon emission gives the branching ratio between the molecular formation rate and the known atomic radiative rate. The molecular spectrum is observed as a continuum whose intensity profile may be used to infer a bound state vibrational distribution at each [X]. Both bound and quasibound states are included in this distribution, as both contribute to the observed molecular spectra. The low pressure limit of this distribution yields the teratomic recombination rate as a function of binding energy, and the total recombination rate constant k_f. It is generally found that this distribution per quantum state is almost independent of binding energy; i.e., the probability of molecular formation appears to be about the same for all bound states, it does not favor the highest bound levels. When the density of states is considered, weakly bound molecules are formed more frequently, but this weighting depends on the shape of the potential rather than the gas temperature. Comparison with theoretical models is made, and reasons for the discrepancies are discussed.

16218. Fanconi, B., **On the assignments of rotatory lattice modes in *n*-alkanes and polyethylene,** *J. Appl. Phys.* **46,** No. 10, 4124-4129 (Oct. 1975).

Key words: *n*-alkanes; polyethylene; Raman spectroscopy; rotatory lattice modes.

Considerable discrepancy exists in the recent literature on the assignments of the rotatory lattice modes of the *n*-alkanes and polyethylene. New low-temperature Raman data are presented on orthorhombic *n*-alkanes and on $n\text{-}C_{36}D_{74}$ and $n\text{-}C_{16}D_{34}$. Analyses of these data and the existing assignments show that the long-axis rotatory mode of the triclinic *n*-alkanes may be assigned to a weak Raman band at ~50 cm^{-1}; the A_g rotatory mode of polyethylene may be assigned to the Raman band at ~130 cm^{-1} and the B_{3g} rotatory mode to a weak Raman band at 108 cm^{-1}.

16219. Reneker, D. H., Fanconi, B., **Effects of defects on the longitudinal acoustic mode of *n*-alkane chains,** *J. Appl. Phys.* **46,** No. 10, 4144-4147 (Oct. 1975).

Key words: localized defects; *n*-alkanes; polyethylene; Raman-active longitudinal acoustic mode.

Normal mode calculations show that a single conformational defect in an otherwise all-trans *n*-alkane molecule disrupts the longitudinal acoustic mode (LAM) associated with the all-trans molecule. Similar calculations for a chain in the conformation produced by smoothly twisting a planar zigzag through 180° about the chain axis show that the LAM amplitudes and frequencies are unaffected by this gentle twist. These calculations indicate that the decrease in the LAM intensity observed in some polyethylene samples cannot be accounted for by smoothly twisted chains, but can be accounted for by defects which involve large localized departures from the all-trans conformation.

16220. Kusuda, T., Tsuchiya, T., Powell, F. J., **Prediction of indoor temperature by using equivalent thermal mass response factors,** (Proc. 5th Symp. on Temperature, Washington, DC, June 21-24, 1971), Paper in *Temperature, Its Measurement and Control in Science and Industry,* L. G. Rubin, A. C. Anderson, J. E. Janssen, and R. D. Cutkosky, Eds., Part 2, **4,** 1345-1355 (Instrument Society of America, Pittsburgh, PA, 1972).

Key words: on-line simulation of temperature controls; thermal response factors.

Several methods are explored for computing room temperature and room thermal load from outdoor conditions. An analytical method based upon rigorous heat transfer analysis of the building system requires a sophisticated computer program and a large computer. A stochastic time series method based upon experimental data of a limited time duration is attractive because it does not rely upon a complex heat transfer mathematics simulation. The stochastic processing of the experimental data, however, leads to the response factors which are physically inconsistent. A semiempirical method, based upon a finite difference solution of a differential equation modeling the equivalent thermal mass system, produced consistent and accurate results. Although this approach has only been verified using experimental data of very simple boundary conditions (without solar radiation effect and the internal heat generation), the results are very promising and encourage further study. Applications are mentioned, such as a simplified on-line computerized linear function temperature control system and, a means of predicting energy requirements for buildings.

16221. Moore, L. J., Gramlich, J. W., Machlan, L. A., **Application of isotope dilution to the high accuracy trace analysis of environmental and health standards,** (Proc. 9th Annual Conf. on Trace Substances in Environmental Health, Columbia, MO, June 11, 1975), Paper in *Trace Substances in Environmental Health-IX,* D. D. Hemphill, Ed., pp. 311-316 (1975).

Key words: cadmium; environmental Standard Reference Materials; isotope dilution; lead; molybdenum; rubidium; strontium; trace analyses.

During the last few years at the National Bureau of Standards, isotope dilution mass spectrometry (IDMS) has been extensively applied to the determination of trace elements in a variety of matrices. The cumulative result of recent developments in analytical methodology, such as the lowering of analytical blanks and thermal ionization enhancement techniques, has been the extension of the high accuracy capability of IDMS to more than 20 elements at the ppm (μg/g) and ppb (ng/g) levels with commensurate accuracies of < 0.25-0.50 percent (relative ts, where $ts = t_{n-1}(0.95)$ sample standard deviation) for most of these elements. Applications of these techniques to selected elements in biological and environmental standard reference materials will be presented.

The efficacy of IDMS as a reference trace analytical tool is also being utilized for the development of accurate analysis techniques using the more frequently field-employed atomic absorption and emission spectrometry. This approach has been applied to Ca and Pb in porcine, bovine and human blood where the typical IDMS determinations are 0.1894 ± 0.0009 ppm and 84.09 ± 0.17 ppm for Pb and Ca, respectively. A brief comparison of these and comparable data from absorption and emission techniques will be presented.

16222. Luther, G. G., Towler, W. R., Deslattes, R. D., Lowry, R., Beams, J., **Initial results from a new measurement of the Newtonian gravitational constant,** (Proc. Atomic Masses and Fundamental Constants, Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants,* J. H. Sanders and A. H. Wapstra, Eds., **5,** 592-598 (Plenum Publishing Corp., New York, NY, 1976).

Key words: acceleration measurement; fundamental constant; gravitational attraction; gravitational constant; rotating reference frame.

A redetermination of the Newtonian gravitational constant is underway at the National Bureau of Standards, Gaithersburg, Maryland, USA. This measurement is expected to yield results, eventually, in the 10 to 20 ppm range. An initial measurement with relatively low accuracy has been completed and some refinements are now in progress which show promise of better results.

16223. Deslattes, R. D., **Recent estimates of the Avogadro constant,** (Proc. Atomic Masses and Fundamental Constants, Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., **5,** 552-558 (Plenum Publishing Corp., New York, NY, 1976).

Key words: Avogadro; crystal; physical constant; x ray.

The present day situation of the Avogadro constant is reviewed. In the course of various recent adjustments, first the x-ray route and then the electrochemical Faraday had to be excised over the past several years. This then left a unique indirect electrical route which leads to a 6 ppm value. More recently, a new x-ray cell size, crystal density and atomic weight determination was carried out with 1 ppm claimed accuracy. The principal features of this are summarized.

16224. McCarter, R. J., **Smoldering of flexible polyurethane foam,** *J. Consum. Prod. Flammability* **3,** 128-140 (June 1976).

Key words: cotton; cushioning; fire retardant; furniture; glowing; inhibitor; oxidative pyrolysis; oxygen index; rayon; smoke; smoldering; upholstery fabric.

The smoldering behavior of various flexible polyurethane foams was studied. All foams smoldered when exposed to cigarette and fabric smolder, posing degrees of potential hazard. A few foams exhibited self-sustained smolder and were judged exceptionally hazardous.

Smolder behavior was compared to oxygen indices, density, permeability, and charring tendencies of the foams. A significant correlation was found between smoldering and charring (opposed to melting) tendencies. Distinctly different combustion behavior was noted for foams based on conventional polyols versus grafted polyols, and for foams containing fire retardant additives. Possibilities for modifying smolder behavior are discussed.

16225. Horowitz, E., **Plastics testing,** Paper in *Kirk-Othmer Encyclopedia of Chemical Technology, 2d Edition,* **15,** 811-832 (John Wiley & Sons, Inc., New York, NY, 1968).

Key words: nonpolymeric constituents in plastics; plastics testing; polymer analysis; properties; test methods.

Plastics are tested to measure one or more of their properties and to relate these measurements to predictable or observable behavior. These tests permit quality to be judged and the properties of plastics to be modified and improved. They also provide data on the fundamental nature and characteristics of plastics, which furthers our understanding of these systems. This chapter serves as an introduction to the subject of plastics testing and briefly describes some of the important tests that are made on plastic materials.

16226. Snell, J. E., **Summary Review—Evaluation factors, design requirements and needed research,** (Proc. Symp. CIB (Conseil Internationale du Batiment) Commission W62 on Water Supply and Drainage Inside Buildings, Watford, England, Sept. 19-20, 1972), Paper in *Water Demand in Buildings*, pp. 117-126 (Dept. of the Environment, Watford, England, Nov. 1973).

Key words: plumbing; plumbing research; water demand in buildings; water distributing systems.

This paper presents a framework for evaluation of water demands in buildings, which was used to review and summarize the papers presented at the Building Research Establishment Symposium on Water Demand in Buildings. This symposium was held in conjunction with the first meeting of CIB Commission W62 on Water Supply and Drainage.

This framework identifies principal uses of water in buildings, the determinants of water demands, and the basic issues which must be addressed in developing improved predictive models and water supply and distributing system design procedures. Significant contributions in the symposium papers are noted, in particular experimental methodology and theoretical models.

The paper concludes by identifying important and relevant issues not addressed in the symposium papers and by summarizing needed research. Meaningful data on observed patterns of water use remain a major research need. Other needs include a more accurate and workable methodology for predicting future water demands and for design of water supply and distribution systems.

16227. Deslattes, R. D., Kessler, E. G., Sauder, W. C., Henins, A., **Visible to gamma-ray wavelength ratio,** (Proc. Atomic Masses and Fundamental Constants, Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., **5,** 48-53 (Plenum Publishing Corp., New York, NY, 1976).

Key words: crystal diffraction; gamma-ray wavelength; gold 198; goniometer; x-ray interferometry.

We report on procedures and a preliminary result for a measurement of the wavelength of the ^{198}Au 412 keV line relative to that of a molecularly stabilized laser in the visible. The measurement involves: optical interferometry of a Si lattice repeat distance; transfer from a sample of the Si crystal to Ge crystals; and angle measurement for the γ-ray line diffracted by the Ge crystals by means of angle interferometry.

16228. Melmed, A. J., Carroll, J. J., **Three-color direct superposition for field-ion microscopy,** *J. Appl. Phys. Commun.* **47,** No. 8, 3762-3763 (Aug. 1976).

Key words: color superposition photography; field-ion microscopy; image analysis; three-color superposition.

Direct two-component color superposition for field-ion microscopy is extended to three-component color superposition. Details of the method are given and some applications are mentioned.

16229. Crawford, M. L., **Improved techniques and instrumentation for EMC measurements,** *Proc. IEEE Int. Symp. on Electromagnetic Compatibility, Washington, DC, July 13-15, 1976*, pp. 369-374 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: electromagnetic compatability; EMC instrumentation; measurements.

This paper presents a survey of improved measurement techniques, instrumentation, and data presentation for accurate, meaningful evaluation of electromagnetic compatibility (EMC) of electronic systems and subsystems. These techniques and instrumentation were developed as alternatives to conventional, MIL-STD-461/462, measurements which recommend screen room testing with conventional antennas. These alternatives are used to accurately measure and quantify EM emissions from electronic equipment and/or for establishing standardized EM susceptibility test fields. Dramatic improvement (worst case errors of 1 to 3 dB compared with 40 dB from conventional screen room measurements) have been demonstrated. The techniques described in the paper include: 1) low-Q or underground enclosures, 2) mode stirred, shielded enclosures, 3) specially designed, shielded, transverse electromagnetic (TEM) cells, 4) broadband field probes capable of measuring complex average or peak fields without causing perturbation, and 5) time and amplitude statistics for characterizing the measured data.

16230. Brown, W. E., Gregory, T. M., **Calcium pyrophosphate crystal chemistry,** *Arthritis Rheum.* **19,** No. 3, 446-462 (May-June 1976).

Key words: calcium diphosphate; calcium pyrophosphate; chondrocalcinosis; pseudogout; solubility; solubility product; synovial fluid.

Theoretical considerations governing the solubilities of calcium pyrophosphates are presented in terms of phase diagrams and calculations based on an ionic model, and the reliability of reported solubility data is examined in terms of the model. The solubility product constant, $(Ca^{2+})^2(P_2O_7^{4-})$, of $Ca_2P_2O_7 \cdot 2H_2O$ appears to be in the vicinity of 3×10^{-18}, but some of the data indicate that it may be as high as 10^{-14} to 10^{-13}. Recommendations are given for the future experimental measurements.

16231. Barbrow, L. E., **Changeover to metric—Timetable and Government role,** Paper in *Metrication—Managing the Industrial Transition,* R. G. Liptai and J. W. Pearson, Eds., Am. Soc. Test. Mater. Spec. Tech. Publ. 574, pp. 22-31 (July 1975).

Key words: conversion to metric; government metrication; metrication; metric system; SI; timetable for metrication.

The changeover to the metric system in the United States is motivated by our manufacturing industry. The basic reason for the changeover is economic necessity, which dictates also that changes to metric be made only where they are advantageous. In the transition timetable, our manufacturing industry and our educational institutions are already well started. Now, then, is the time also for the development of national metric engineering standards to supersede or supplement our customary engineering standards. Government procurement will keep in step with industry changeover. Consumer products will be changed some years hence, the specific time being dependent on the enactment of national metric legislation, but early programs should be initiated to keep our public informed as to why the changeover is taking place and how it is progressing. The principal role of Government in the changeover is to keep SI, the modernized metric system, as clean as possible. When metric legislation is enacted, a National Metric Conversion Board will have the responsibility for coordinating the changeover. Meanwhile the American National Metric Council has undertaken this role.

16232. Arp, V., **Negative differential flow resistance in supercritical helium,** *Cryogenics* **16,** No. 3, 171-177 (Mar. 1976).

Key words: flow resistance; helium; Ledinegg instability; negative flow resistance; supercritical helium.

The study of helium flow instabilities occurring in large helium cooling systems is important for the future development of these systems. One of these instabilities, the Ledinegg instability, is caused by negative differential flow resistance. This paper discusses the conditions under which a negative differential flow resistance can occur and finds that it will not occur in single phase helium cooling systems except under certain very restricted conditions.

16233. Benjamin, I. A., Adams, C. H., **The flooring radiant panel test and proposed criteria,** *Fire J.* **70,** No. 2, 63-70 (Mar. 1976).

Key words: fire hazard; fire safety; flooring test; radiant panel.

The objective of this discussion is to present background and other technical data that will help in suggesting criteria to be used in conjunction with the Flooring Radiant Panel Test to determine the potential contribution to fire growth of floor covering systems for use in corridors and exitways.

16234. Haller, F. B., Hessel, M. M., Neef, W., Lai, W., Lohr, H., **Concentric heat pipe cavity for e-beam excited lasers,** *Proc. 6th Symp. on Engineering Problems of Fusion Research, San Diego, CA, Nov. 17-21, 1975,* pp. 79-83 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: electron beam excitation; heat pipe oven; lasers; metal vapors; noble gas; spectroscopy.

A concentric heat pipe oven for metal vapor-noble gas mixtures has been designed and constructed as a high power laser cavity for laser fusion applications. A 1 MeV, 100 KA, 50 ns e-beam is injected into this oven through a stainless steel foil window, 0.125 mm thick. Details of the construction and design considerations of the heat pipe oven, foil window and safety features are given.

16235. Torchia, D. A., Lyerla, J. R., Jr., Deber, C. M., **Carbon-13 chemical shifts of amides and imino acid residues. Effects of the carbonyl substituent and *syn-anti* geometries,** *J. Am. Chem. Soc. Commun. to Editor* **96,** No. 15, 5009-5011 (July 24, 1974).

Key words: amides; carbon-13 magnetic resonance; chemical shifts; cis and trans isomers; peptides; proline; ring conformation; substituent effects.

Differences in C-13 chemical shifts, ΔC^i, for carbons *syn* and *anti* to the carbonyl oxygen ($\Delta C^i = \tau_{syn} - \tau_{anti}$) are reported for a series of N,N′-diethylamides and model peptides containing imino acid residues. The model compound data show that cis and trans peptide bond isomers account for the ΔC^i values observed in polypeptides containing pyrrolidine residues (L-prolyl and hydroxyl-L-prolyl) when the effects of *syn-anti* geometry and the carbonyl substituent are considered.

16236. Allan, D. W., Mungall, A. G., Winkler, G. M. R., **Comments on the 25 April 1975 paper in "Science" entitled: "Terrestrial timekeeping and general relativity—A discovery,"** *Science* **191,** 489-490 (Feb. 6, 1976).

Key words: atomic clocks; clock acceleration effect; definition of the second; frequency accuracy; frequency standards; general relativity; gravitational redshift; primary frequency standards; proper time; UTC.

We wish to clarify some essential points relative to the paper "Acceleration and Clocks," by W. H. Cannon and O. G. Jensen. Cannon and Jensen have developed two contradictory equations based on different relativistic assumptions and have attempted to "resolve the contradictions" using data tabulated by the Bureau International de L'Heure (BIH) on atomic clocks located at various places in North America and Europe. The atomic clock data Cannon and Jensen have used are those for the UTC_i, where the i denotes the Observatory and/or Laboratory generating a particular Coordinated Universal Time Scale. We are obliged to state that Cannon and Jensen's assumption that "the intervals on the time scales UTC_i of the contributing Observatories... correspond to the adopted definition of the second" is not valid at the accuracy level they need to test the contradiction between their equations.

The experimental data used by Cannon and Jensen contain inaccuracies and systematic effects which render invalid their conclusion of "A Discovery" in general relativity. To the contrary, experimental data do exist which contradict Cannon and Jensen's conclusion that an "observer's" perception of the world geometry depends on his state of acceleration."

16237. Jones, R. N., **Electronic eavesdropping techniques and equipment,** *LESP-RPT-0207.00,* 40 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: body worn antenna; bugging; eavesdropping; electronic surveillance; microphones; receiver; tape recorder; telephone; transmitter; wiretapping.

This report describes some of the methods and equipment used for electronic audio surveillance. The subject of countersurveillance (defensive) equipment and techniques, while not completely excluded, is confined to the minimum necessary to the understanding of offensive surveillance activity. Both radiating and hard wire methods are discussed along with the advantages, disadvantages and limitations of each. Particular attention is given to the subject of body worn transmitters and the operational problems associated with their use including batteries and body mounted antennas. Experimental data is included to illustrate some of the principles and problems surrounding their use. The conclusion includes recommendations of various items for inclusion in a standard for body worn transmitters. A fairly extensive annotated bibliography is also provided.

16238. Richmond, J. C., **Active night vision devices,** *NILECJ-STD-0305.00,* 31 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: contrast transfer function; distortion; flare; image intensifier tubes; infrared searchlights; infrared viewers; light equivalent background; light induced background; optical gain.

An active night vision device consists of a viewer incorporating a single-stage image intensifier tube with an S-1 photocathode, that is sensitive to light at wavelengths out to about 1.1 μm, and an infrared searchlight which usually makes use of a quartz halogen lamp and an infrared filter that blocks all visible light. The standard describes test procedures for evaluating optical gain, light induced background, light equivalent background, contrast transfer function, flare and distortion of the viewer, and effective range of the searchlight, and establishes minimum levels of performance for these criteria.

16239. Richmond, J. C., **Passive, first generation night vision devices,** *NILECJ-STD-0304.00,* 25 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: contrast transfer function; flare; image intensifiers; law enforcement; light equivalent background; light induced; optical gain; night vision.

The Standard establishes test methods and performance criteria for passive, hand-held night vision devices for use in law enforcement. The viewers covered by this Standard are of the three-stage image intensifier type, that were originally developed for military use.

Test procedures and performance requirements are listed; (A) for (1) focus adjustment, (2) curvature of field, and (3) distortion of eyepiece lenses; (B) for (1) optical gain, (2) optical gain stability, (3) light equivalent background, (4) light induced background, (5) luminance of output screen, (6) luminance uniformity, (7) cathode and screen quality, (8) contrast transfer function, (9) distortion, and (10) flare of a night vision device complete with objective lens, but with the eyepiece removed; (C) for resistance to (1) vibration, (2) high and low temperature storage, (3) thermal shock, and (4) humidity of night vision device complete with both objective and eyepiece lenses; and (D) for (1) boresight adjustment, (2) click movement, and (3) resistance to mechanical shock of night vision devices intended for use as rifle sights.

16240. Bennett, L. H., Page, C. H., Swartzendruber, L. J., **Comments on units in magnetism,** (Proc. 21st Annual AIP Conf. No. 29, on Magnetism and Magnetic Materials-1975, Philadelphia, PA, Dec. 9-12, 1975), Paper in *Magnetism and Magnetic Materials-1975,* J. J. Becker, G. H. Lander, and J. J. Rhyne, Eds., 3 pages (American Institute of Physics, New York, NY, 1975).

Key words: magnetism; units.

Suggestions are given on how to express magnetic quantities in SI units.

16241. Ramsburg, R. E., Aronoff, M. J., **Calculation by digital computer of minimum station-to-station distances in the United States railroad network,** *Report No. DOT P 6300.1,* 46 pages (Department of Transportation, Washington, DC, June 1972).

Key words: railroad freight movements; short-line miling system; waybills.

This volume is the first of a series of two documents which report a package of computer programs developed by the Technical Analysis Division of the National Bureau of Standards for the computation of "short-line" distances. The "short-line" distance between two stations in a rail network is defined as the shortest route between them over which carload traffic can be moved without transfer of lading. The network treated in this specific application was the continental United States railroad system. After its development, the package was used to "mile" the 1969 Waybill File.

Volume one outlines the background of the project, defines the general problem, describes the alternative methodologies considered, and outlines the final solution.

Volume two is both an operations manual for personnel who will annually operate the computer programs to calculate short-line distances for the Waybill File, and a programmer's manual providing technical descriptions and flow charts for each of the computer programs in the short-line "miling" package.

The programs which were developed for this project, and the partitioning technique employed, can be modified to carry out similar calculations for other large networks.

16241. Ramsburg, R. E., Batten, D. R., **Programmer level documentation of the short line mileage programs for the United States railroad network,** *Report No. DOT P 6300.1,* 106 pages (Department of Transportation, Washington, DC, June 1972).

Key words: programmer's documentation; short line mileage; waybill file.

This volume is the second of a series of two documents which report a package of computer programs developed by the Technical Analysis Division of the National Bureau of Standards for the computation of "short-line" distances. The "short-line" distance between two stations in a rail network is defined as the shortest route between them over which carload traffic can be moved without transfer of lading. The network treated in this specific application was the continental United States railroad system. After its development, the package was used to "mile" the 1969 Waybill File.

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The programs which were developed for this project, and the partitioning technique employed, can be modified to carry out similar calculations for other large networks.

16242. Hougen, J. T., **Calculation of vibrational level populations in multiphoton absorption processes,** *J. Chem. Phys.* **65,** No. 3, 1035-1041 (Aug. 1, 1976).

Key words: floquet theory; laser-induced reactions; multiphoton processes; numerical calculations; relaxation phenomena; vibrational populations.

A simple procedure is described for computing steady-state excited vibrational state populations for multiphoton absorption processes in many-level systems. The procedure utilizes techniques already in the literature, i.e., expansion of the density matrix as a Fourier series in the frequency of the monochromatic radiation field, and introduction of linewidths and thermal relaxation by the addition of empirical terms to the density matrix time-development equation. Numerical computations can be carried out quickly on idealized systems, using commercially available band matrix inversion routines. A sample calculation for a 10-level, nine-photon process is presented.

16243. Wachtman, J. B., Jr., **Ceramic materials in high temperature gases: Fundamental behavior controlling lifetime in coal conversion applications,** (Proc. Ceramic Materials in High Temperature Gases on Materials Problems and Research Opportunities in Coal Conversion, Columbus, OH, Apr. 16-18, 1974), Paper in *Materials Problems and Research Opportunities in Coal Conversion* **2,** 335-343 (The Department of Metallurgical Engineering, The Ohio State University, Columbus, OH, 1974).

Key words: ceramics; coal conversion; coal gasification; corrosion; fracture; vaporization.

The degradative processes which ceramics in high temperature gases produced by coal conversion may undergo are briefly reviewed. These include purely chemical processes such as combination of liquids in cracks and subsequent corrosion. These also include chemical modification of physical processes of deterioration such as environmental effects in fracture.

16244. Bovey, F. A., Schilling, F. C., McCrackin, F. L., Wagner, H. L., **Short-chain and long-chain branching in low-density polyethylene,** *Macromolecules* **9,** No. 1, 76-80 (Jan.-Feb. 1976).

Key words: branching; limiting viscosity numbers; long-chain branching; nuclear magnetic resonance; polyethylene; short-chain branching.

The branch content of two fractions of low-density polyethylene has been examined by ^{13}C NMR (at 25 MHz) and by limiting viscosity number (intrinsic viscosity) measurements. The ^{13}C spectra, interpreted with the aid of modified Grant-Paul chemical shift rules and the spectra of model copolymers, confirm that the principal type of short branch is trifunctional *n*-butyl (5-6 per 1000 CH_2) with smaller contents of *n*-amyl (ca. 2 per 1000 CH_2) and ethyl (ca. 1 per 1000 CH_2). A resonance at (32.1$_6$) ppm (from TMS), corresponding to the third carbon (C-3) from the branch end, provides a measure of branches longer than *n*-amyl, but does not at present distinguish such branches, presumably formed by intramolecular "backbiting," from the truly "long" branches, containing possibly many tens or hundreds of carbons and formed by intermolecular chain transfer to other polymer chains. If it is assumed that this resonance provides in fact a direct measure of the "long" branch content, "short" branches longer than *n*-amyl being of negligible probability, the results agree well with the long branch content estimated from the intrinsic viscosities of branched and linear polyethylene via the Simm-Kilb *g* value. The long branch content thus deduced is ca. 0.8 per 1000 CH_2. For these samples, no marked dependence on molecular weight is observed for either the long- or short-branch frequencies.

16245. Davis, R. M., **National policies for information processing: Situation in the United States,** (Proc. 2d Jerusalem Conf. on Information Technology, Jerusalem, Israel, July 29-Aug. 1, 1974), Paper in *The 2d Jerusalem Conference on Information Technology: Computers for Social and Economic Development*, C. C. Gotlieb and H. Maisel, Eds., **1,** 15-27 (1974).

Key words: executive programs; information management; information processing; legislative programs; national policies; public concern.

The topic of a National Policy for Information Processing in the United States would be short-lived if it were broached as a direct question, for the answer would be "No, there is no such national policy!" However, discussions of the changing national interest in information and of emerging national concerns with information and its processing in the United States will give evidence of an increased national awareness of information processing.

Similarly, a description and status of certain legislative and executive programs in the general area of information processing will furnish some idea of current, widely-impacting problem areas and ongoing efforts to resolve them on a nation-wide or government-wide basis. Finally, public concern and involvement with information processing will be described to highlight the increasingly-intense interaction between information technology and the public.

With this broader interpretation of the topic in terms of: Changing national interest in information; emerging national concerns with information and its processing; legislative and executive programs in the general area of information processing; current, widely-impacting problem areas in information processing; and public concern and involvement with information and its processing, a perspective can be obtained of national policy in-the-making.

16246. Linden, T. A., **The use of abstract data types to simplify program modifications,** (Proc. Conf. on Data: Abstraction Definition and Structure, Salt Lake City, Utah, Mar. 22-24, 1976), *SIGPLAN Notices 11, Special Issue, Assoc. Comput. Mach.-FDT* **8,** No. 2, 12-23 (Association for Computing Machinery, New York, NY, Mar. 1976).

Key words: abstract data types; class; cluster; data abstraction; data type; module; programming methods; program modifications; type.

If a program is structured using abstract data types as the basic unit of modularity, then that program is much easier to extend or modify. This thesis is illustrated by the staged development of a program to compute prime numbers based on the sieve of Eratosthenes. This paper includes an extensive introduction to the concept of abstract data types and can be used as a tutorial survey. It includes discussions on the use of abstract data types in connection with recent approaches to data abstractions, hierarchical structure, and program design. Abstract data types are an extension and modification of the traditional concept of data type. An abstract data type defines not only a data representation for objects of the type but also the set of operations that can be performed on objects of the type. Furthermore, the abstract data type can protect the data representation from direct access by other parts of the program.

16247. Abrams, M. D., **Measuring service delivered in interactive computing,** (Proc. 2d Jerusalem Conf. on Information Technology, Jerusalem, Israel, July 29-Aug. 1, 1974), Paper in *The 2d Jerusalem Conference on Information Technology: Computers for Social and Economic Development*, C. C. Gotlieb and H. Maisel, Eds., **1,** 747-754 (1974).

Key words: computer; interactive; measurement; procurement; response; service.

This paper considers the measurement of service rendered by interactive computer systems and application of these measurements to the procurement process. Topics discussed include what to measure; response, psychological, throughput, and cost-benefit considerations; when to measure; where to measure; how to measure; measurement conditions; and data analysis. Ongoing efforts at ICST are presented as examples of the state of the art.

16248. Muehlhause, C. O., **Costs, real and perceived, examined in a risk-benefit decision framework,** (Proc. OECD Conf. on Costs, Real and Perceived, Examined in a Risk-Benefit Decision

Framework, Paris, France, Aug. 1972), Paper in *Environmental Damage Costs*, pp. 282-304 (Director of Information, OECD, Paris, France, 1974).

Key words: consumer product hazard; risk-benefit.

The so-called problem of risk-benefit is analyzed with special emphasis on the case of consumer products which exhibit hazard as well as utility. The market demand is represented as a function of two independent factors: a vital one re safety, and a utilitarian one to which dollar values may be assigned. The condition for optimization of the net public benefit is examined along with its dependence on costs. The general ideas developed are extended to some more complex cases and regimes.

16249. Casella, R. C., **Possible failure of the Pomeranchuk Theorem. Shrinkage of the forward elastic peak and oscillations,** (Proc. "Ettore Majorana" School of Subnuclear Physics, Erice, Sicily, July 1-19, 1970), Paper in *Elementary Processes at High Energy*, A. Zichichi, Ed., 519-525 (Academic Press, Inc., New York, NY, 1971).

Key words: asymptotics; elastic; oscillations; Pomeranchuk; shrinkage; theorem.

Under rather general assumptions, it is shown that if the Pomeranchuk Theorem fails such that $\sigma_+(s) \rightarrow$ unequal constants, then the differential elastic cross section $d\sigma/dt$ oscillates wildly with t as well as exhibiting a $(\ln s)^2$ shrinkage of the forward peak.

16250. Muehlhause, C. O., **Risk benefit analysis,** *ASTM Stand. News* **1,** No. 2, 8-13 (Feb. 1973).

Key words: consumer product hazard; risk-benefit.

The so-called problem of risk-benefit is analyzed with special emphasis on the case of consumer products which exhibit hazard as well as utility. The market demand is represented as a function of two independent factors: a vital one re safety, and a utilitarian one to which dollar values may be assigned. The condition for optimization of the net public benefit is examined along with its dependence on costs. The general ideas developed are extended to some more complex cases and regimes.

16251. Finnegan, T. F., **Superconductivity in dc voltage metrology,** (Proc. Summer Course on the Science and Technology of Superconductivity, Georgetown University, Washington, DC, Aug. 13-26, 1971), Paper in *The Science and Technology of Superconductivity*, W. D. Gregory, W. N. Mathews, Jr., and E. A. Edelsack, Eds., **2,** 565-585 (Plenum Press, New York, NY, 1973).

Key words: ac Josephson effect; low-temperature voltage divider; superconducting tunnel junctions; voltage standard.

The simple theory of the ac Josephson effect in a tunnel junction is presented and recent work on the development and implementation of a national voltage standard based on measurements of the fundamental physical constant 2e/h is reviewed. The principle problems associated with the design and construction of conventional-type high-accuracy low-voltage dividers are treated, and the role of the cryogenic potentiometer and superconducting null detector in a Josephson-effect voltage standard is explored. Finally, a possible secondary voltage standard based on Giaever tunneling is described.

16252. Eitzen, D. G., Chwirut, D. J., **Ultrasonic reference blocks and characterized fatigue cracks,** (Proc. ARPA/AFML Review of Quantitative Nondestructive Evaluation, Thousand Oaks, CA, July 15-17, 1975), Paper in *Proceedings of the ARPA/AFML Review of Quantitative NDE, Technical Report AFML-TR-75-212*, pp. 107-127 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, Jan. 1976).

Key words: acoustic emission; aluminum; fatigue cracks; flat bottomed holes; standards; steel; titanium; transducer calibration; ultrasonic reference blocks.

Work in progress on the improvement of ASTM E127 type ultrasonic reference blocks (flat bottomed holes) and on the development of well characterized fatigue crack is described. A data base for aluminum reference blocks has been developed by borrowing sets of field blocks and obtaining the response using 2.25, 5, and 10 MHz transducers. Steel and titanium blocks are also studied. Considerable effort has been expended in order to evaluate the contributions of metallurgical condition, physical dimensions and fabrication methods to the variability of the reference blocks. The variability due to different measurement systems and different operators was also quantified to an extent. Several possible methods of providing improved standards are suggested.

While standard defects such as cracks seem impractical to produce, it seems feasible to produce well characterized cracks. Work on characterizing fatigue cracks produced in standard ASTM E399 compact tension specimens has centered on controlling as many of the variables affecting ultrasonic response as possible. The affect of the remaining variables on ultrasonic response will be characterized. The fatigue loading program is controlled to produce nominally identical cracks. Six different techniques for measuring the physical characteristics of the cracks are being evaluated and generally show good correlation.

Techniques which have been developed for the calibration of ultrasonic and acoustic emission transducers are noted in passing.

16253. Langhoff, P. W., Corcoran, C. T., **Tchebycheff-derivative approximations to photoabsorption cross sections in atoms and ions,** *Chem. Phys. Lett.* **40,** No. 3, 367-371 (June 15, 1976).

Key words: atomic spectroscopy; photoabsorption.

Spectral moments and Tchebycheff's inequalities are employed in the construction of continuous, convergent approximations to photoabsorption and ionization cross sections in atoms and ions.

16254. Unassigned.

16255. Deslattes, R. D., Henins, A., Schoonover, R. M., Carroll, C. L., Bowman, H. A., **Avogadro constant – Corrections to an earlier report,** *Phys. Rev. Lett. Comments* **36,** No. 15, 898-900 (Apr. 12, 1976).

Key words: Avogadro constant; crystals; lattice parameter.

Corrections are required to values of silicon crystal density and lattice parameter used in our determination of N_A. The corrections are of the order of 1 ppm but taken together result in a change of the previously reported value of 0.03 ppm. A published suggestion that the lattice-parameter measurement might require a much larger correction appears unsupported.

16256. Bulos, B. R., Phelps, A. V., **Excitation of the 4.3-μm bands of CO_2 by low-energy electrons,** *Phys. Rev. A* **14,** No. 2, 615-629 (Aug. 1976).

Key words: carbon dioxide; cross section; electrons; excitation; infrared; rate coefficient.

Rate coefficients for the excitation of the 4.3-μm bands of CO_2 by low-energy electrons in CO_2 have been measured using a drift-tube technique. The CO_2 density [(1.5 to 7)$\times 10^{17}$ molecules/cm^3] was chosen to maximize the radiation reaching the detector. Line-by-line transmission calculations were used to take into account the absorption of 4.3-μm radiation. A small fraction of the approximately 10^{-8} W of the 4.3-μm radiation produced by the approximately 10^{-7}-A electron current was incident on an InSb photovoltaic detector. The detector calibration and absorption calculations were checked by measuring the readily calculated excitation coefficients for vibrational excitation of N_2 containing a small concentration of CO_2. For pure CO_2 the number of molecules capable of emitting 4.3-μm radiation

produced per cm of electron drift and per CO_2 molecule varied from 10^{-17} cm^{-2} at $E/N = 6 \times 10^{-17}$ V cm^2 to 5.4×10^{-16} cm^{-2} at $E/N = 4 \times 10^{-16}$ V cm^2. Here E is the electric field and N is total gas density. The excitation coefficients at lower E/N are much larger than estimated previously. A set of vibrational excitation cross sections is obtained for CO_2 which is consistent with the excitation coefficient data and with most of the published electron-beam data.

16257. Ayres, T. R., Linsky, J. L., **The Mg II *h* and *k* lines. II. Comparison with synthesized profiles and Ca II K,** *Astrophys. J.* **205,** No. 3, Part 1, 874-894 (May 1, 1976).

Key words: radiative transfer; solar chromosphere; solar photosphere; solar ultraviolet spectrum.

We compare the Mg II *h* and *k* resonance line data of Kohl and Parkinson and profiles of the Ca II K line with synthetic spectra computed using a partial redistribution formalism and several single-component solar upper photosphere and lower chromosphere models. We find that the HSRA and Vernazza *et al.* (VAL) models predict systematically lower intensities in the *h*, *k*, and K inner wings than are observed, but that models with a somewhat larger minimum temperature ($T_{min} \approx 4450$ K), such as proposed previously by Shine *et al.*, can reproduce the measured inner wing intensities and limb darkening of these resonance lines. Upper photosphere temperature distributions with $T_{min} \approx 4450$ K are also more consistent with the radiative equilibrium models of Athay (non-LTE) and Kurucz (LTE), when nonradiative energy dissipation is taken into account. We propose a "hot" T_{min} solar model, which is reasonably consistent with the empirical emission cores and wing intensities of the Ca II and Mg II resonance lines, to serve as an alternative to the class of models, such as the HSRA and VAL, based on continuum observations.

16258. Schnaus, U. E., Schroeder, J., Haus, J. W., **Subcritical viscosity anomaly in sodium silicate glasses,** *Phys. Lett.* **57A,** No. 1, 92-94 (May 17, 1976).

Key words: correlation length; Ginzburg-Landau theory; glass; inhomogeneous system; subcritical region; viscosity.

A subcritical viscosity anomaly is reported in binary mixtures of Na_2O-SiO_2. The results are discussed qualitatively in terms of inhomogeneities which are present in the system.

16259. Mann, W. B., Huchinson, J. M. R., **The standardization of iodine-129 by beta-photon coincidence counting,** *Int. J. Appl. Radiat. Isot. Tech. Notes* **27,** No. 3, 187-188 (Mar. 1976).

Key words: beta; coincidence counting; gamma; radioactivity; standardization; ^{129}I.

Sources of ^{129}I quantitatively deposited on ion exchange resin paper were calibrated by means of a simple β-γ coincidence experiment recently performed over a period of a few days at NBS.

16260. Fromhold, A. T., Jr., **Parabolic oxidation of metals in homogeneous electric fields,** *J. Phys. Chem. Solids* **33,** 95-120 (1972).

Key words: conductivity; electric field effects; insulating films; insulators; metal oxidation; metals; MOM devices; oxidation; oxidation theory; parabolic law for metal oxidation; semiconductors.

A previously proposed thin film parabolic growth law (Fromhold, 1963) is extended to include film growth due to any number of diffusing defect species of arbitrary valence, and an analysis is made of the effects of applying external electrostatic potentials during oxidation. The total electrical conductivity and the partial conductivities are, markedly position-dependent in the protective film, varying by orders of magnitude from one interface to the other. The built in electrostatic potential across the film is independent of thickness of the film and is a function of the partial conductivities of the diffusing ionic and electronic defect species. Effects of electrical shorting of the oxide film by external circuitry are analyzed. Depending on polarity, a constant applied potential can increase or decrease the rate constant but does not alter the kinetics from the parabolic form, in accordance with published experimental data. The net electrostatic potential required to stop metal oxidation is derived for the model in question. For growth by a single ionic species, the stopping potential is that electrostatic potential which gives an equal electrochemical potential at the metal-oxide and the oxide-oxygen interfaces. For growth by multiple ionic species, the stopping potential is a function of the ionic partial conductivities.

16261. Carlsten, J. L., Szöke, A., **Collisional redistribution of near-resonant scattered light in Sr vapour,** *J. Phys. B Letter to Editor* **9,** No. 9, L231-L235 (1976).

Key words: collisions; near-resonant scattering; redistribution; strontium.

Strontium vapour was irradiated by a dye laser tuned near the 460.73 nm ($^1P_1{}^0$-$^1S_0$) resonance transition. Collision-induced fluorescence at the resonance frequency and Rayleigh scattering at the laser frequency were studied as a function of detuning Δ over a range of about 30 nm (1500 cm^{-1}). The Rayleigh component was found to vary as Δ^{-2}, as expected, whereas the collision-induced fluorescence was markedly asymmetric. This experiment constitutes a direct measurement of the redistribution function.

16262. Chen, S. T., Gallagher, A., **Excitation of the Ba and Ba$^+$ resonance lines by electron impact on Ba atoms,** *Phys. Rev. A* **14,** No. 2, 593-601 (Aug. 1976).

Key words: barium; electron impact; excitation.

The relative optical excitation functions and polarizations of the Ba resonance line (5535 Å) and of the Ba$^+$ resonance lines (4554 and 4934 Å) have been measured, using crossed electron and barium-atom beams. The Ba 6^1P excitation function has been normalized to the Bethe theory in the high-energy limit, and the excitation functions of the ionic lines have been measured relative to that of the atomic resonance line. Using spontaneous-emission branching ratios for the Ba$^+$(6^2P) levels, we have also obtained normalized cross sections for these ionizing excitation levels. From a few electron volts above threshold, the Ba$^+$(6^2P) ionizing-excitation cross section has nearly the same energy dependence as has been reported for the total Ba$^+$ ionization cross section, but about 1/6 the magnitude. In particular, a broad maximum at ~22 eV, attributed to core-excited autoionizing levels, apparently contributes an equal fraction to both cross sections. This relationship holds also for the ionizing excitations versus total ionization of Sr. The cross sections for exciting the resonance levels of He, Mg, Ca, Sr, and Ba are also intercompared in reduced units and found to be strikingly similar at collision energies above ~3 times the threshold energies.

16263. Suzuki, G., Carter, C., Lieblein, J., Murphey, W. M., Perella, F. J., Smith, C. N., **Safeguards accountability analysis in a nuclear fuel processing plant,** Paper in *Safeguards Systems Analysis of Nuclear Fuel Cycles, WASH-1140 Safeguards and Nuclear Materials Management UC-15,* 46 pages (Office of Safeguards and Materials Management, U.S. Atomic Energy Commission, Washington, DC, Oct. 1, 1969).

Key words: material balance accounting; nuclear materials safeguards; process losses.

Material accounting constitutes an important, if not the principal means for suspecting and detecting diversions of Special Nuclear Material (SNM). Since the nature of SNM and the processes involved preclude precise identification of all the material through its various physical transformations within a plant, or within any part of the nuclear fuel cycle, the detection of diversions through an accounting system depends upon knowledge of the expected values and variabili-

ties of the recorded losses under diversion-free conditions. This paper examines the variations of material unaccounted for (MUF) derived from material balance accounts, and reports on attempts to isolate the various components of MUF for a selected nuclear processing operation.

16264. Smith, J. C., **The elastic constants of a particulate-filled glassy polymer: Comparison of experimental values with theoretical predictions,** *Polym. Eng. Sci.* **16,** No. 6, 394-399 (June 1976).

Key words: bulk modulus; composite materials; elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; shear modulus; Young's modulus.

Calculation of the elastic constants of a particulate composite material in terms of the elastic constants of the filler and the matrix is discussed. The theories of Kerner or Hashin and Shtrikman, the equivalent theories of Budiansky and Hill, and a generalized van der Poel type theory are presented and discussed. Data from several sources are compared with the predictions of these theories. The van der Poel theory provides the best agreement and gives good values for volume fractions of filler up to 0.35.

16265. Calvano, N. J., Dobbyn, R. C., **Riot helmets,** *NILECJ-STD-0104.00,* 15 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1974).

Key words: helmets; impact attenuation; penetration; retention system strength; riot; visual clearance.

This standard establishes performance requirements and methods of test for helmets used to protect the wearer during civil disturbances, riots or other situations that pose a threat of injury from blows to the head. The test methods described measure the ability of the helmet to attenuate impact, resist penetration and provide sufficient peripheral visual clearance and test the static strength of the helmet's retention system. It is based on ANSI standard Z90.1-1971.

16266. Fey, R. L., **Automatic vehicle location techniques for law enforcement use,** *LESP-RPT-0205.00,* 27 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1974).

Key words: automatic vehicle locator; car locators; law enforcement.

Automatic vehicle location systems employing communications techniques are presently under development by several companies. This report discusses such systems with respect to law enforcement applications. It presents the principles upon which the various automatic location techniques are based, summarizes their important characteristics, and compares them as candidates for law enforcement use. This report discusses techniques, available system performance, and the related aspect of frequency spectrum requirements for these systems. It also mentions areas where more operational information is needed before systems for law enforcement operations can be clearly defined.

16267. Robertson, B., Baumgarten, G. P., **Evaluation of automotive fuel flowmeters,** (Proc. Project Coordination Meeting of the Automotive Energy Efficiency Program, Cambridge, MA, Nov. 4-6, 1975), *Report No. DOT-TSC-OST-76-1,* 20 pages (Available from the National Technical Information Service, Springfield, VA 22161, June 1976).

Key words: automotive environment; calibration; low flow rates.

A description is given of laboratory apparatus and procedures for evaluating gasoline flowmeters under conditions simulating the automotive environment. Preliminary results are reported on tests of three commercially available automotive fuel flowmeters.

16268. Eicke, W. G., Jr., **The volt, yesterday, today and tomorrow,** (Proc. PSA Int. Conf., Chicago, IL, Oct. 4-7, 1971), *ISA Reprint 71-703,* pp. 1-7 (Oct. 1971).

Key words: electrical standards; standard cells; U.S. legal volt; volt; voltage measurement.

Of all the electrical quantities used today, the unit of voltage is probably the most difficult to maintain, disseminate and use properly. This paper briefly discusses the history of the volt to 1967. Work at NBS after 1967 is described. Developments are reported in four basic areas: 1) The application of statistical design and digital computers to obtain additional information about the measurement process, 2) improvements in the equipment for making standard cell measurements, 3) improvement in the temperature control of standard cells, and 4) improved techniques for disseminating the volt. To further improve the volt, the progress for maintaining surveillance over the unit by means of the gyromagnetic ratio of the proton and the Josephson effect are discussed.

16269. Cook, R. K., **Acoustic emissions—Researchers in Japan,** *Sci. Bull.* **1,** No. 1, 17 pages (June-Sept. 1976).

Key words: acoustic emission; acoustics; flaw detection; nondestructive inspection.

While in Japan in the summer of 1975, I undertook an investigation, at the request of the Office of Naval Research, into the current state of Japanese research techniques and technological applications of acoustic emissions (AE). The investigation was done mainly by means of visits to laboratories and conferences with physicists and engineers working on AE in the Tokyo area. The visits and conferences were held during the week of 1-5 September 1975. All of the conferences were on an unclassified basis. In addition, various published papers describing Japanese researches on AE have been studied. Most of these are in the *List of Publications* of the Report. The list includes about 40 publications from Japanese laboratories working on acoustic emissions.

16270. Fuller, E. G., Hayward, E., Eds., **Photonuclear reactions,** *Book—Benchmark Papers in Nuclear Physics* **2,** 426 pages (Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA, 1976).

Key words: history; photonuclear experiments; photonuclear interaction; photonuclear reactions; photonuclear theory; reprint collection.

A collection of 43 reprints of research papers which have made a significant impact on the development of the photonuclear physics field are presented. Comments associated with each paper place it into the context of the historical development of the field, and indicate the particular contributions each paper has made to the development of an understanding of the nuclear photoeffect and nuclear structure. The papers are all concerned with classical photonuclear physics, the interaction of real photons having energies less than 150 MeV with nuclei. The field of inelastic electron scattering is not treated.

16271. Panek, R. J., Savage, B. D., **Ultraviolet photometry from the orbiting astronomical observatory. XXIII. The resonance lines of triply ionized carbon and silicon in the spectra of hot stars,** *Astrophys. J.* **206,** No. 1, 167-181 (May 15, 1976).

Key words: absorption; B-stars; C IV; O-stars; Si IV; spectra; stellar; ultraviolet.

Quantitative measurements of the absorption strength of the Si IV (1400 Å) and C IV (1550 Å) resonance doublets have been made from OAO-2 far-ultraviolet spectra of 118 O- and B-type stars. These lines are generally very strong and a useful measure of their strength can

be made even though the OAO-2 scans have relatively low spectral resolution (FWHM = 12 Å). However, variable amounts of line blending limit the accuracy of the results to approximately ± 1 to 2 Å in the equivalent width. For dwarf stars the strength of both features correlates well with spectral type or temperature. The Si IV doublet peaks in strength near spectral type B1 with a total equivalent width of about 5 Å in agreement with the theoretical non-LTE (NLTE) plane-parallel static models of Kamp. The C IV doublet in dwarfs rapidly increases in strength from B2 to B0 and attains an equivalent width of about 5 Å at spectral type O9. For both doublets we note a large increase in the absorption equivalent width with luminosity classification, the increase amounting to a factor of 2 to 3 between dwarfs and supergiants. In the luminous O stars we also note a change in the line profile to the P Cygni type. In the case of the Si IV line for stars cooler than spectral type B0.5 the observed luminosity effect is roughly consistent with the predictions of static NLTE models. However, for the O stars the static models predict a *decrease* in equivalent width with increasing luminosity. The differences between theory and observation are associated with the effects of mass outflow.

The observations include a number of B stars with peculiar visual spectra. With the exception of θ Car, which exhibits an abnormally weak C IV line, the various peculiar stars observed appear to have normal Si IV and C IV line strengths.

For a group of rapidly rotating stars the C IV line appears marginally stronger than expected on the basis of MK classification, while Si IV appears normal. In the case of the Be shell star, γ Cas, we have noted a factor of 2 increase in the strength of Si IV and C IV over a time scale of months.

With the exception of ξ^1 CMa and β Cep, the Si IV and Ce IV lines in a group of 11 β Cephei variables appear to have strengths consistent with their MK classification.

A number of repeated observations of bright early-type stars were searched for absorption line variability on time scales ranging from minutes to years. With only a few exceptions no variability was found. The sample included a number of luminous O supergiants, suggesting that the mass loss from these objects occurs as a steady process.

16272. Mihalas, D., Kunasz, P. B., Hummer, D. G., **Solution of the comoving-frame equation of transfer in spherically symmetric flows. III. Effect of aberration and advection terms,** *Astrophys. J.* **206,** No. 2, 515-524 (June 1, 1976).

Key words: radiative transfer; relativistic effects; spectral line formation; stellar atmospheres.

We investigate the importance of the advection and aberration terms, which are of order V/c, in the comoving-frame transfer equation in spherical geometry. Characteristic trajectories are found which reduce the spatial derivatives to a perfect differential, and a generalization of the numerical procedure developed in the earlier papers of this series that permits the integration of the transfer equation on these characteristics is presented. For cases in which $V/c \ll 1$, a perturbation solution is developed which reduces the problem to that solved in the first paper in this series. For velocities of the form $V(r) \sim r^n (n = 0, 1, 2)$, it is shown that the magnitude of the effects arising from the advection and aberration terms is about $5V/c$ relative to the solution with these terms omitted. In stellar winds $V/c < 0.01$; hence we conclude that aberration and advection terms may safely be ignored, and that consideration of the Doppler-shift term alone is adequate in the computation of spectra from such expanding atmospheres.

16273. Swartzendruber, L. J., Evans, B. J., **Nuclear gamma ray resonance observation of the activation process in Raney iron and Urushibara iron catalysts,** *J. Catal.* **43,** 207-219 (1976).

Key words: catalysis; Mössbauer effect; Raney-iron-activation.

The phases that form when Raney iron and Urushibara iron catalysts are activated have been studied utilizing ^{57}Fe nuclear gamma ray resonance. For Raney iron catalysts four phases are observed in the activated catalyst; residual aluminum-depleted Raney alloy, $Fe(OH)_2$, α-Fe and Fe_3O_4. The relative proportions of phases present is a sensitive function of leaching temperature and time. For Raney iron catalysts, and for Urushibara iron catalysts prepared using aluminum, no alloying of aluminum into the activated phases is observable. For Urushibara iron catalysts prepared using zinc, there is considerable alloying of iron and zinc. Evidence is presented to show that when the catalyst is generated at low temperatures $Fe(OH)_2$ is a precursor phase for metallic Fe in Raney Iron. A similar situation seems to exist for the Urushibara catalyst prepared using aluminum. The alloying behavior of the iron catalysts can be understood on the basis of the nature of the intermediate phase. The large amounts of Fe_3O_4 present in Raney iron prepared at elevated temperatures raises some questions concerning the catalytically active phases in such materials.

16274. Peterlin, A., **Crystallization from a strained melt or solution,** *Polym. Eng. Sci.* **16,** No. 3, 126-137 (Mar. 1976).

Key words: crystallization; cylindrite; drawing of swollen polymer solid; epitaxial overgrowth; extrusion; hard elastomer; nucleation; oriented melt; rheological unites; row nucleus; shishkebab; sonicated solution; spinning; stirred solution.

The elongation and orientation of randomly coiled macromolecules in a strained melt or solution reduces their entropy and thus increases the crystallization or melting temperature of the ideal lattice. At any given temperature of the experiment this enhances nucleation and crystal growth rate. As a rule, linear primary nuclei are formed. They contain more or less extended chains. The existence of row nuclei reduces the local gradient in the liquid to such an extent that further crystallization proceeds by epitaxial overgrowth of folded chain lamellae. Densely packed cylindrites are formed with the ribbon-like lamellae radiating from the central row nucleus. The irregular shish-kebab structure observed in stirred or sonicated solutions seems to be formed by subsequent axial deformation of cylindrites in the flow field. It displaces the lamellae irregularly and thus produces a great many microfibrillar elements parallel to the original row nuclei. The almost completely extended chains in the shish yield a high elastic modulus and tensile strength for axial loading. The shish-kebab morphology in fibers as spun does not affect to a great extent the mechanical properties obtainable by subsequent drawing. The lamellae are transformed into microfibrils in very much the same manner as in spherulitic samples. But the highly regular orientation of lamellae seems to result in a more uniform drawing and hence a stronger fiber. In an extremely high temperature and pressure gradient, the melt extrusion produces hard elastomers where the lamellae of the cylindrites seem to be locally stapled. Upon application of tensile load in the extrusion direction, the intervening sections bend like beams, thus forming thin holes extending in the direction-perpendicular to the load. The holes enormously enhance the permeability for gases and liquids. The elastic bending of lamellae yields the high recoverable strain and low tensile modulus.

16275. Phillips, J. C., Mattamal, M. M., **Correlation of liquid heat capacities for carboxylic esters,** *J. J. Chem. Eng. Data* **21,** No. 2, 228-232 (Apr. 1976).

Key words: correlation; esters; heat capacity; oligomers; sebacates; triglycerides.

Liquid heat capacity data of carboxylic esters (including a sebacate series, triglyceride series, and oligomer series), covering a temperature range from 20 to about 180 °C and a molecular weight range from 116 to 939, were determined with a differential scanning calorimeter. The data, together with published heat capacity values, were reduced to a temperature independent correlation. The results suggest an ap-

proximate additivity in carboxyl content and a lack of dependence on structural type (e.g., linear, branched, or oligomeric).

16276. Unassigned.

16277. Mopsik, F. I., Broadhurst, M. G., **Molecular dipole electrets,** *J. Appl. Phys.* **46,** No. 10, 4204-4208 (Oct. 1975).

Key words: dipoles; electret; glass; piezoelectric; polarization; polyvinyl chloride; pyroelectric.

The total polarization due to molecular dipoles in a glassy electret is computed using an Onsager cavity approach. From this result, all the possible contributions to the piezoelectric and pyroelectric coefficients are considered. It is shown that there are major contributions from the variation in dielectric constant and, for pyroelectricity, from thermal motion. These results account well for experimental data for polyvinyl chloride.

16278. Penn, R. W., Kearsley, E. A., **The scaling law for finite torsion of elastic cylinders,** *Trans. Soc. Rheol.* **20,** No. 2, 227-238 (1976).

Key words: elasticity; finite torsion; natural rubber; scaling law; simple materials assumption.

The torque and forces normal to the end surfaces of cylinders of natural rubber were measured as a function of the angle of twist. The measurements were repeated on small cylinders cut from the larger cylinders to insure that the tests were on identical material. Plots of reduced torque and of reduced normal force versus reduced twist for the different sized cylinders coincide to within 1 percent. This result supports the simple material assumption of the classical theory of finite elastic deformations. An interesting instability was observed, and derivatives of the strain energy function were calculated.

16279. Fanconi, B., Crissman, J., **Influence of methyl group branches on the longitudinal acoustical mode frequencies in alkanes and polyethylene,** *J. Polym. Sci. Polym. Lett. Ed.* **13,** 421-426 (1975).

Key words: alkanes; longitudinal acoustical mode; methyl group branches; polyethylene; Raman spectroscopy.

The Raman-active longitudinal modes (LAM) of crystalline n-alkanes have been extensively studied. The frequency-chain length relationship found for the n-alkanes has been recently used to deduce the length of the all-trans chain segments in polyethylene single crystals and to determine the paraffinic chain lengths and conformations in phospholipids. The use of LAM frequencies of n-alkanes in this manner neglects the effects of interchain interactions, terminal chain groups, and conformational or mass defects.

16280. Horowitz, E., **Transfer of measurement methodology to industry,** *J. Assoc. Eng. Archit. Isr.* **35,** 21-41 (May 1976).

Key words: benefits, industry-society; materials research; measurements-standards; NBS-industry; transfer.

The National Bureau of Standards (NBS) is engaged in a variety of measurement and standards activities, many of which are applicable to the solution of scientific and technological problems in industry and society. This paper discusses some of the innovations and accomplishments resulting from the materials programs in the NBS Institute for Materials Research and traces the work from the laboratory phase to the transfer and utilization of measurement technology and standards in industry. Also included is a brief discussion of the NBS Experimental Technology Incentives Program (ETIP) which is concerned with stimulating the implementation of innovative policies in the area of science and technology.

16281. MacDonald, R. A., Tsai, D. H., **Molecular dynamical calculations of the thermal diffusivity of a perfect lattice,** (Proc. 14th Int. Conf. on Thermal Conductivity, Storrs, CT, June 2-4, 1975), Paper in *Proceedings of the 14th International Conference on Thermal Conductivity,* P. G. Klemens and T. K. Chu, Eds., pp. 145-152 (Plenum Press, New York, NY, 1976).

Key words: continuum theory of diffusion; density; kinetic temperature; molecular dynamics; numerical error; perfect lattice; thermal conductivity; thermal diffusivity; thermo-elastic coupling.

We have used the method of molecular dynamics to make a detailed study of thermal diffusivity in a perfect monatomic lattice. The interatomic potential is that appropriate for iron. We limit the atomic motions to two dimensions in order to shorten the computation. We maintain one end of the lattice at a given kinetic temperature and obtain the temperature profile in the lattice as a function of time. The total energy added to the system is recorded. We fit diffusive curves to the temperature profiles and thus obtain the thermal diffusivity of the lattice. Its value is 4×10^{-6} m^2 sec^{-1} at a mean lattice temperature of 75K.

16282. Bucaro, J. A., Simmons, J. H., **Rayleigh wave study of surface diffusion and stress relaxation in glass,** *J. Non-Cryst. Solids* **14,** 225-241 (1974).

Key words: glass; glass strengthening; ion exchange; Rayleigh waves; surface waves.

Surface wave propagation on ion-exchanged glass surfaces has been systematically studied. The glass system was an alkali-alumino silicate glass, and the ion-exchange involved the replacement of lithium ions by sodium ions. Accurate velocity measurements were carried out on systems ion-exchanged for various times and at various temperatures. The effects of density and modulus changes on the velocity have been separated. Stress build-up and relaxation have been observed which correlate well with shear viscosity measurements. In addition, the diffusion coefficient for the $Na^+ \rightleftarrows Li^+$ exchange has been determined at a variety of temperatures.

16283. DiMarzio, E. A., **Validity of the Ehrenfest relation for a system with more than one order parameter,** *J. Appl. Phys.* **45,** No. 10, 4143-4145 (Oct. 1974).

Key words: Ehrenfest relation; glassy state; order-parameters; polymer thermodynamics.

The relation $\Delta C_p \Delta \kappa = TV(\Delta\alpha)^2$ is shown to be obeyed under the same assumptions that Davies and Jones used to derive the weaker condition $\Delta C_p \Delta \kappa \geq TV(\Delta\alpha)^2$. This means that if a material is found experimentally not to obey the above equality, then it is not describable by an order-parameter theory. A prescription is given which allows one to determine within the context of order-parameter theory whether the glass transition of a given material is basically thermodynamic or kinetic in origin.

16284. Broadhurst, M. G., Harris, W. P., Mopsik, F. I., Malmberg, C. G., **Piezoelectricity, pyroelectricity and electrostriction in polymers,** *Polym. Prepr.* **14,** No. 2, 820-829 (Aug. 1973).

Key words: electret; piezoelectricity; polarization electrostriction; polymer; pyroelectricity.

Piezoelectricity in naturally-occurring biological and polarized synthetic polymers is becoming increasingly recognized as an important phenomenon. This paper traces the history of piezoelectricity in electrets and gives a simple physical basis for the effect. Measurement techniques are described and piezo- and pyroelectric data for polymers are presented and compared to data for common non-polymeric materials.

16285. Taggart, H., Nelson, R. E., Scott, W., Jr., Shafer, J., Tary, J., Workman, J., Treado, M. J., **Personal/portable FM transmitters,** *NILECJ-STD-0203.00,* 22 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of

Law Enforcement and Criminal Justice, Washington, DC, Oct. 1974).

Key words: audiofrequency modulation; communications; electromagnetic compatibility; law enforcement; personal transmitter; portable transmitter; radio frequency carrier; transmitter.

The purpose of this standard is to establish performance requirements and the test methods needed to evaluate these requirements for frequency modulated personal/portable transmitters used by law enforcement agencies. Sixteen transmitter characteristics are included. Also described are a radiation test site, standard duty cycle and the characteristics of required test equipment.

16286. Treado, M. J., Taggart, H. E., Nelson, E., Scott, W. W., Shafer, J. F., Tary, J. J., **Fixed and base station FM transmitters,** *NILECJ-STD-0201.00*, 20 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1974).

Key words: base station transmitter; communications; fixed transmitter; FM transmitter; law enforcement; transmitter.

The purpose of this standard is to establish performance requirements and methods of test for FM fixed and base station transmitters used by law enforcement agencies. It should be used with transmitters which either do not have subsystems such as selective signaling or in which such subsystems are disabled or bypassed. This standard is applicable to transmitters licensed to operate in the 25-50 MHz, 150-174 MHz, and 400-512 MHz bands, and includes the performance requirements and test methods for 16 different transmitter characteristics.

16287. Calvano, N. J., Dobbyn, R. C., **Crash helmets,** *NILECJ-STD-0105.00*, 13 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: crash; helmet; impact attenuation; penetration; retention system strength; visual clearance.

This standard establishes performance requirements and methods of test for helmets used to protect the wearer while a driver or passenger of a surface vehicle. The test methods described measure the ability of the helmet to attenuate impact, resist penetration and provide sufficient peripheral visual clearance and test the static strength of the helmets' retention system. It is based on ANSI Standard Z90.1-1971.

16288. Hartman, A. W., **Proposed image space scanner with reduced off-axis defocusing,** *Opt. Eng.* **15,** No. 3, 262-264 (May-June 1976).

Key words: defocusing; image space off-axis; line scanner; optical.

An optical line scanner with a scanning mirror between the optics and the image can be modified to produce more than twice the field of view of a conventional image space scanner, without increase in off-axis defocusing. The proposed approach consists of moving the rotation center of the scanning mirror away from a point on the optical axis to a specified point off-axis.

Two examples of such a scanner modification are analyzed: a flat-field microscope scanner with high resolution and a curved-field night-viewing scanner with high optical speed.

16289. Crissman, J. M., **On the transition from paraffinic to polymeric behavior: Mechanical properties,** *J. Polym. Sci. Part A-2*, **13,** 1407-1416 (1975).

Key words: chain folds; differential scanning calorimetry; linear polyethylene fractions; low angle x ray; mechanical relaxation; tetranonacontane.

An attempt has been made to determine what influence chain folds may have on the α and γ mechanical loss peaks in linear polyethylene. In so doing, one long-chain n-paraffin ($C_{94}H_{190}$) and two low molecular weight polyethylene fractions have been examined with mechanical relaxation, differential scanning calorimetry (DSC), and low-angle x-ray diffraction techniques. The data suggest that chain folds play a prominent role in both the α and γ processes but that other factors such as polydispersity and/or branching are also important.

16290. DiMarzio, E. A., Bishop, M., **Connection between the macroscopic electric and mechanical susceptibilities,** *J. Chem. Phys.* **60,** No. 10, 3802-3811 (May 15, 1974).

Key words: Cole-Cole plots; dielectric constants of polymers; dielectrics; electric dispersion; permeability of polymers.

The following relationship is derived between the dielectric permittivity $\epsilon(\omega)$ and the complex shear viscosity $\eta(\omega)$: $[\epsilon(\omega)-\epsilon_\infty]/(\epsilon_0-\epsilon_\infty)=[1-i\omega\eta(\omega)K]^{-1}$. This equation is derived from both a generalization of Debye's treatment and from the Kubo formalism. The model consists of dipoles imbedded in rigid beads that are in turn imbedded in the viscous medium. A frequency dependent $\eta(\omega)$ implies nonexponential decay of the electric dipoles and results in skewed-arc behavior in the Cole-Cole plots except when $\eta(\omega)$ is represented by a single Maxwell element or by a single Voigt element. Consistency with the requirements of causality and reality is displayed. Experimental $\epsilon(\omega)$ are predicted reasonably accurately by use of experimental $\eta(\omega)$ and the above equation.

16291. Edelman, S., **Piezoelectric polymer transducers,** *Proc. Workshop on Sonar Transducer Materials, Naval Research Laboratory, Washington, DC, Nov. 13-14, 1975*, pp. 269-282 (Naval Research Laboratory, Washington, DC, Feb. 1976).

Key words: flexibility; hydrophone; impedance match; low-cost transducers; piezoelectric polymers.

Polymers with significant piezoelectric activity have been developed. This material can be used to measure many forms of dynamic stress and vibration. Piezoelectric polymers can be formed in size and shape to suit a particular application and they can be fastened to curved, twisted, or compliant surfaces.

A typical piezoelectric polymer is compared with a typical piezoelectric ceramic for underwater use. A new polymer hydrophone is described whose sensitivity in the region below 1 kHz is comparable to that of conventional hydrophones.

16292. Tighe, N. J., Swann, P. R., **Magnetite lamellae in reduced hematites,** Chapter 4.3 in *Electron Microscopy in Mineralogy*, H. R. Wenk, et al., Eds., pp. 209-213 (Springer-Verlag Berlin Heidelberg, Germany, 1976).

Key words: electron microscopy; Fe_2O_3; Fe_3O_4; high-voltage electron microscopy; *in situ* hematite; magnetite.

Microstructural changes that occur during gaseous reduction of hematite (Fe_2O_3) were studied by light and electron microscopy. Reduction experiments carried out in a high-voltage electron microscope and in a controlled atmosphere furnace showed that at T = 1000 °C magnetite nucleates and grows with the $(111)_m \| (0001)_h$ habit. Lenticular magnetite plates grow by a martensitic mechanism.

16293. Arthur, M. G., Saulsbery, L. F., Scott, W. W., Jr., Shafer, J. F., **Mobile FM receivers,** *NILECJ-STD-0207.00*, 18 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: FM receivers; law enforcement equipment;

minimum performance requirements; NILECJ Standard; receiver definitions; receiver measurement techniques.

This document is a voluntary performance standard that establishes minimum performance requirements and methods of test for Mobile FM Receivers used by law enforcement agencies. This standard specifies the test conditions, the test equipment needed, the test methods, and the minimum performance requirements necessary for satisfactory performance in Mobile FM Receivers.

16294. Jickling, R. M., **RF coaxial cable assemblies for mobile transceivers,** *NILECJ-STD-0212.00*, 9 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: cable assembly; coaxial cable; insertion loss; mobile antenna; mobile transceiver; transmission.

This standard specifies the connector plug at the mobile transceiver for an rf coaxial cable lead-in from a mobile antenna. Four performance requirements are listed, with detailed test methods for measuring characteristics such as standing wave ratio and insertion loss.

16295. Calvano, N. J., Dobbyn, R. C., **Ballistic helmets,** *NILECJ-STD-0106.00*, 13 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: armor; ballistic helmet; ballistic impact; ballistic penetration; bulletproof helmet.

NILECJ-STD-0106.00, Ballistic Helmets, is a law enforcement equipment standard developed by the Law Enforcement Standards Laboratory. It establishes minimum performance requirements and methods of test for helmets intended to protect the head against gunfire. Standards are established for helmets intended to provide two levels of protection: helmets protective against caliber .357 Magnum revolver fire, and helmets protective against caliber .38 Special and .22 long rifle high velocity handgun fire.

16296. Jesch, R. L., Scott, W. W., Treado, M. J., **Batteries for personal/portable transceivers,** *NILECJ-STD-0211.00*, 14 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: battery performance standard; law enforcement communications, Law Enforcement Standards Laboratory; personal/portable transceivers; primary battery; secondary battery; transceiver.

This document is a voluntary performance standard for batteries used in personal/portable transceivers. It establishes minimum performance requirements and methods of test for primary and secondary batteries, and is intended to assist law enforcement agencies in the selection and procurement of these batteries.

16297. Arthur, M. G., Saulsbery, L. F., Scott, W. W., Jr., Shafer, J. F., **Personal/portable FM receivers,** *NILECJ-STD-0208.00*, 18 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1975).

Key words: FM receivers; law enforcement equipment; minimum performance requirements; NILECJ Standard; receiver definitions; receiver measurement techniques.

This document is a voluntary performance standard that establishes minimum performance requirements and methods of test for personal/portable FM receivers used by law enforcement agencies. This standard specifies the test conditions, the test equipment needed, the test methods, and the minimum performance requirements necessary for satisfactory performance in personal/portable FM receivers.

16298. Teague, M. R., Lambropoulos, P., Goodmanson, D., Norcross, D. W., **Theory of two-photon ionization of cesium,** *Phys. Rev. A* **14,** No. 3, 1057-1064 (Sept. 1976).

Key words: cesium; multiphoton processes; photoionization.

We present a systematic theoretical analysis of two-photon ionization of cesium in the perturbation-theory regime. Matrix elements from diverse sources, such as quantum-defect theory and model potentials, as well as from experimental oscillator strengths, have been used in the calculation. The results are discussed in the context of recent measurements. In addition to total generalized cross sections (gcs) for linearly polarized light, ratios of gcs for linear to circular polarization, as well as photoelectron spin polarization, have been calculated. The various sets of matrix elements give results which are consistent, given variations that should be expected from the diversity of the sources. The disagreement with experiment, however, persists.

16299. Cooper, J. W., **Inner shell ionization as a single electron process,** (Proc. Int. Conf. on Inner Shell Ionization Phenomena and Future Applications, Atlanta, GA, Apr. 17-22, 1972), Paper in *Proceedings of the International Conference on Inner Shell Ionization Phenomena and Future Applications*, R. W. Fink, S. T. Manson, J. M. Palms, and P. V. Rao, Eds., CONF-720404, **2,** 807-815 (USAEC Technical Information Center, Oak Ridge, TN, Jan. 1973).

Key words: charged particle excitation; inner shells; ionization; photoionization.

Excitation ionization of inner shell electrons by photons, protons, electrons or heavy charged particles can be viewed within a common theoretical framework provided the interaction of the incident particle with the system being bombarded is sufficiently weak. Within this approximation the ionization process depends only on the energy and momentum transferred to the ionized system and may be characterized by a "Bethe Surface" in these variables. Quantitative calculations of specific processes and interpretation of experimental data often considers ionizations as a single electron (two-body) process. The basic theory of inner shell ionization treated as a single electron process will be reviewed briefly with emphasis on its range of validity and the relationship between information obtained via excitation by different incident particles.

16300. Davis, R. M., **Preventive technology: A cure for scientific ills,** *Science* **188,** No. 4185, 213 (Apr. 1975).

Key words: preventive technology; scientific ills; society and science; technology and civilization.

Preventive Technology: A Cure for Scientific Ills is an editorial dealing with scientific advancement and hopes that preventive technology can prohibit further societal side effects. Scientific discoveries are often linked with the harm that they may cause humanity rather than the good that they do (e.g., computer science is coupled to an undesirable "data bank;" and the development of synthetic plastics is linked with environmental pollution).

Prevention of scientific ills in the past and even today has taken place after the fact. It is important to recognize that science has been the primary cause of beneficial change throughout man's history. Preventive technology needs to be recognized as a scientific specialty. It must be practiced as part of every aspect of science. It will make possible both more science and more public peace of mind. Delay in setting up Preventive Technology may cause ill for both science and for future beneficial changes for society.

16301. Berger, H., **Nondestructive measurements: How good are they?,** *Mater. Eval.* **XXXIV,** No. 1, 18A-20A, 22A, 24A, 33A-34A (Jan. 1976).

Key words: accuracy; conservation; measurements; nondestructive evaluation; productivity; reliability; reproducibility; safety.

Increasing demands are being made on nondestructive evaluation (NDE) as a result of needs for safety, conservation, and productivity. This makes it all the more imperative that NDE measurements be made in a reliable, reproducible manner. The capabilities of NDE measurements are considered from the points of view of elements of the system and the measurement system as a whole. In each case, unacceptable variations in measurement accuracy, reliability, and reproducibility are identified. The NDE measurement situation is compared to measurements being made in clinical chemistry, where an improved measurement capability was brought about through the efforts of the professionals in that field, and the development of standard reference materials and measurement methods of known accuracy. The NDE community is called upon to take similar steps and contribute to the needs for improved NDE measurements and standards.

16302. Franklin, A. D., **Electrochemical growth of crystals from electrolyte solutions,** *J. Cryst. Growth* **34,** 245-247 (1976).

Key words: calcium hydroxide; crystal growth; crystals, electrochemical; electrolysis; solution.

An electrochemical crystal-growth technique is described in which an electrolyte reaction involving one ion in the desired crystal is used to create a concentration gradient in that ion across the cell. Nutrient material held near the consuming electrode is dissolved, and crystal growth near the producing electrode occurs at a rate which can be controlled by the current through the cell. The technique has been demonstrated with the growth of $Ca(OH)_2$ crystals from aqueous solutions of $CaCl_2$ plus KCl.

16303. Arthur, M. G., Saulsbery, L. F., Scott, W. W., Jr., Shafer, J. F., **Fixed and base station FM receivers,** *NILECJ-STD-0206.00,* 17 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: FM receivers; law enforcement equipment; minimum performance requirements; NILECJ Standard; receiver definitions; receiver measurement techniques.

This document is a voluntary performance standard that establishes minimum performance requirements and methods of test for fixed and base station FM receivers used by law enforcement agencies. This standard specifies the test conditions, the test equipment needed, the test methods, and the minimum performance requirements necessary for satisfactory performance in fixed and base station FM receivers.

16304. Fanconi, B., Finegold, L., **Vibrational states of the biopolymer polyglycine II: Theory and experiment,** *Science* **190,** 458-460 (Oct. 31, 1975).

Key words: heat capacity; lattice dynamics; low temperature, polyglycine; polypeptides; vibrational states.

The density of vibrational states, and hence the heat capacity, has been calculated for the parallel-chain hexagonal lattice of 3_1 helical polyglycine. The agreement with experimental results in the temperature range from 1 to 20 K, including an anomaly near 8 K, is the best obtained thus far for homopolypeptides.

16305. Dobbyn, R. C., Bruchey, W. J., Jr., Shubin, L. D., **An evaluation of police handgun ammunition: Summary report,** *LESP-RPT-0101.01,* 21 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1975).

Key words: bullets; cartridges; handgun ammunition; law enforcement; relative incapacitation index; relative stopping power.

This report summarizes the results of a laboratory study of handgun ammunition presently being marketed to law enforcement agencies. Three basic terminal effects of the ammunition have been examined: their relative incapacitation potential for human targets, their ricochet behavior and their material penetration characteristics. The focus has been on commercially available handgun ammunition in the caliber range 9 mm (.355 in) to .45. The test methods and evaluation techniques are, however, applicable to other penetrating projectiles.

16306. Lawn, B. R., Swain, M. V., Phillips, K., **On the mode of chipping fracture in brittle solids,** *J. Mater. Sci. Lett.* **10,** 1236-1239 (1975).

Key words: brittle solids; chipping; fracture; indentation; residual stress; stress analysis.

A description is given of the mode of chipping fracture observed in highly brittle solids. It is pointed out that residual stresses about indentation deformation centers play a vital role. The implications of this mode in a number of mechanical phenomena are discussed.

16307. Brown, W. E., Chow, L. C., **Chemical properties of bone mineral,** *Ann. Rev. Mater. Sci.* **6,** 213-236 (Aug. 1976).

Key words: amorphous calcium phosphate; bone mineral; fluorapatite; hydroxyapatite; morphology; nonstoichiometry; octacalcium phosphate; solubility; surface.

The literature on the chemical properties of bone mineral is reviewed. As a basis for understanding the properties of these extremely fine crystallites, reference is made first to the ideal compounds and then to the morphological, compositional, and structural modifications that bone mineral is known or implied to have. The structure of apatite is considered the most suitable prototype for bone crystallites; however, the "apatitic layer" in the crystal of octacalcium phosphate is almost identical in structure to hydroxyapatite. This close structural relationship has many implications relative to the chemistry of bone mineral. "Amorphous calcium phosphate," which has been suggested as a possible component of bone, is assessed. The properties of the so-called "amorphous" material in bone are unlikely to be closely similar to those of synthetic amorphous calcium phosphates. A theoretical basis for solubility of bone is described and its variable solubility is discussed. Because of the smallness of bone crystallites, the surface properties of bone mineral are of great importance. Both the lattice and the surface of the crystallite play important roles in processes involving the dissolution or formation of bone mineral.

16308. Horowitz, E., **Metallo-organic systems with high thermal stability,** Paper 7 in *Advances in Chemistry Series,* R. F. Gould, Ed., No. 85, pp. 82-94 (1968).

Key words: coordination polymers; role of metal and ligand; thermal stability.

When 8-hydroxyquinoline and derivatives of bis(8-hydroxyquinoline) react with metal ions, coordination complexes and polymers are formed, respectively, which exhibit improved thermal stability. This paper reviews the reaction of first-row transition metal ions with such ligands and their effect on the stabilization of these organic molecules. For the polymers containing divalent Mn, Co, Ni, Cu, or Zn the decomposition temperature is related to the periodic properties of the metal as well as the composition of the ligand to which the metal is coordinated. Trivalent chromium produces a crosslinked polymer when it reacts with bis(8-hydroxy-5-quinolyl)methane, and the thermogram for this polymer is also reported.

16309. Chang, S. S., **Low temperature thermal behavior of glassy polymers,** (Proc. ACS Coatings and Plastics 170th Meeting, Chicago, IL, Aug. 25-29, 1975), Paper in *Coatings and Plastics Preprints,* R. F. Wint, Ed., **35,** No. 2, 364-369 (American Chemical Society, Washington, DC, 1975).

Key words: glassy state; glass transition; heat capacity; polymer; specific heat; strain energy; supercooled liquid; thermal relaxation.

A brief review of the thermal behavior of glassy polymers from cryogenic temperatures to the supercooled liquid state will be presented. Results from this and other laboratories will be used to illustrate the following topics of discussion. Some of the recent results from this laboratory were obtained by means of a fully automated adiabatic calorimetric measurement system. The main instrument in the system is a computer-controlled self-balancing potentiometer. Above 25 K, the precision in the heat capacity measurement is about 0.02 percent and the sensitivity in the temperature measurement is about 10^{-3}K.

16310. Berger, R. E., **Dynamic strain gage measurements on ophthalmic lenses impacted by low energy missiles,** *J. Opt. Physiolog. Opt.* **53,** No. 6, 279-286 (June 1976).

Key words: drop-ball test; impact; lens; ophthalmic lens; quasi-static theory; strain gage measurements.

Strain distributions on impacted ophthalmic lenses were measured with strain gages. The strain distributions, which resulted from impacts produced with a special apparatus, were shown to be comparable to those which arise in the FDA drop-ball test. The measured strain drops off very rapidly away from the impact point, implying that only a small part of the lens is really being tested. The results are in good agreement with the quasi-static predictions. The effect of differences in lens power, of input kinetic energy, and of inserting the lens in a polyethylene bag are also investigated.

16311. Berger, R. E., **The role of edge failures in impact testing of ophthalmic lenses,** *J. Am. Optometric Assoc.* **47,** No. 5, 599-605 (1976).

Key words: drop-ball test; edge; fracture; impact; ophthalmic lenses; shape.

The role of edge mode failures in drop-ball testing of ophthalmic lenses was investigated. The relative effects of lens shape and type of edging operation were determined by comparing the impact performance of groups of lenses. Strain gages were mounted on the edges of several lenses to determine the applied tensile stresses. The results were reviewed in the context of the flaw distribution theory. As expected, more breakage was observed for those edging processes which introduce more severe flaws and for those lens shapes for which higher edge stresses were measured. It was also observed that the search theory of impact testing is applicable for edge flaws as well as for surface flaws (a lens sustains many impacts before it fractures; the ball is searching for a weak spot on the lens).

16312. Bennett, L. H., Kahan, D. J., Carter, G. C., **Alloy phase diagram data,** *Mater. Sci. Eng.* **24,** 1-17 (1976).

Key words: alloy; metallurgy; phase diagram.

An annotated list of references including the major compilations of data on alloy phase diagram, crystallography, and thermodynamics and some useful reviews and theoretical discussions of alloy phase diagrams is presented.

16313. Wardell, J. R., Wilmot, G. B., Haar, L., Klein, M., **Thermodynamic data for interior ballistics calculations,** *Proc. 12th JANNAF Combustion Meeting, Newport, RI, July 25, 1975,* pp. 363-390 (Chemical Propulsion Information Agency, Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, 1976).

Key words: equation of state; interior ballistics; water.

The effect on theoretical interior ballistic calculations of real gas corrections to ideal gas thermodynamic quantities is considered. The equation of state of Haar and Shenker for dense spherical gases is generalized to nonspherical gases and applied to water. The agreement with available data is quite good. At 2000 K and 300 MPa (44,000 psi) our theoretical ratio of specific heats differs from that obtained using a simple virial equation of state by 5 percent. This corresponds to a 3.5 percent change in muzzle velocity and maximum pressure. The corresponding difference in Cv is only 2 percent.

16314. Bur, A. J., **Measurements on the dynamic piezoelectric properties of bone as a function of temperature and humidity,** *J. Biomech.* **9,** 495-507 (Sept. 1976).

Key words: bone; dispersion phenomena; Maxwell-Wagner polarization; piezoelectric d constant; piezoelectricity; relative humidity; temperature.

The utilization of piezoelectricity as a clinical or diagnostic tool in medicine and dentistry is dependent upon an adequate quantitative description of the piezoelectric coefficients. Here, measurements of the dynamic piezoelectric d constant, $d^* = d' - id''$, for bovine bone are presented as a function of temperature (20-60 °C), relative humidity (r.h.) (33-98%), frequency of applied stress (10^{-2}-10^{2} Hz), and sample orientation. The anisotropic character of cortical bone requires that d be expressed as a matrix containing 18 coefficients. Dispersion phenomena, i.e. $d'' \neq 0$, are present in these coefficients for our frequency-temperature-r.h. range. At low r.h. ($\leq$75%), d_{12} and d_{13} show little or no dispersion ($d'' = 0$), whereas varying degrees of relaxation are observed in the other coefficients. The d_{14} shear term is notable for a large dispersion at $f = 40$ Hz, $T = 38.6$ °C and 55 percent r.h., for which d''_{14} is negative. The negative imaginary coefficient means that energy is being gained in the 14 coefficient. The change in d_{14}, with a change in temperature and/or r.h., is attributed to a change in sample water content. For 98 percent r.h., the low frequency data ($f < 10$ Hz) are dominated by a polarization which varies as the reciprocal of the frequency. This polarization is attributed to an interfacial or Maxwell-Wagner polarization which occurs as a result of ionic conduction under the influence of the piezoelectric polarization field.

16315. Pierman, B. C., Bryson, J. O., **Building safety research at the National Bureau of Standards,** *Prof. Safety Mag.*, pp. 13-16 (Sept. 1976).

Key words: accidents; buildings; construction; maintenance; research accidents; safety.

This article summarizes the work that is accomplished in the Center for Building Technology to enhance the inherent safety of buildings in the United States. Aspects of user as well as worker safety resulting from building construction, use, maintenance, repair and retrofit are discussed. Research goals and methods, resulting in the greatest impact on overall safety in buildings are enumerated. Specific research projects are summarized.

16316. Margolis, S. A., Howell, B. F., Schaffer, R., **Purification and analysis of the purity of NADH,** *Clin. Chem.* **22,** No. 8, 1322-1329 (1976).

Key words: ADP; ADP-ribose; chromatography; impurities in NADH preparations; NADH stability; preparative chromatography on DEAE-cellulose; spectrophotometric properties of pure NADH.

We developed an analytical reverse-phase high-performance liquid chromatographic procedure for rapid assessment of the purity of NADH. The method completely separates adenosine monophosphate and adenosine diphosphoribose from NADH. By use of this analytical technique we found that preparative chromatography on DEAE-cellulose gives NADH that is free from adenine nucleotides as well as other impurities that commonly are present in NADH. The absorbance ratio at 260 and 340 nm of the purified NADH in 1.8 mmol/liter ammonium carbonate is 2.261 ± 0.002 ($\pm$ 1 SD).

16317. Clark, E. J., Ballard, D. B., Embree, E. J., **SEM examination of an overheated aluminum wired electrical receptacle,** (Proc. 34th Annual Electron Microscopy Society of America Meeting, Miami Beach, FL, Aug. 9-13, 1976), Paper in *34th Annual Proceedings Electron Microscopy Society of America*, G. W. Bailey, Ed., pp. 454-455 (Claitor's Publ. Div., Baton Rouge, LA, 1976).

Key words: aluminum wire; nondispersive x-ray analysis; overheated receptacle; scanning electron microscope.

A typical household electrical receptacle wired with aluminum cable overheated during current cycling tests. It was studied for evidence of the cause of failure. The surfaces of the materials in the electrical path were examined by scanning electron microscopy and energy dispersive x-ray analysis and were found to contain corrosion products of the base materials. Chlorine was also present on the surfaces. A piece of the insulation was also examined. An explanation for the presence of chlorine in the corrosion products is suggested.

16318. Waterhouse, R. V., Cook, R. K., **Diffuse sound fields: Eigenmode and free-wave models,** *J. Acoust. Soc. Am.* **59,** No. 3, 576-581 (Mar. 1976).

Key words: acoustical energy density; acoustics; diffuse sound fields; reflection and interference of sound; room acoustics theory; sound fields.

The diffuse sound field as used in standard measurements in reverberant enclosures has been analyzed in terms of two different models, the eigenmode and the free-wave models. Recently the question has been raised as to the extent to which these models are consistent. To investigate these matters, the energy density as a function of position is calculated for axial, tangential, and oblique modes in a rectangular enclosure. The results show that, for a sound field consisting of several overlapping oblique modes, excited by a narrow band of noise, increases of mean sound pressure levels at the walls, edges, and corners of the enclosure are predicted that are in agreement with the results of the free-wave analysis and experiment. It is concluded that the two models are consistent. The implications of the models, regarding the spatial uniformity of energy, are discussed.

16319. Davis, R. M., **The computer serves, the consumer relishes,** *Comput. Dec.*, pp. 31-34 (May 1975).

Key words: automation; consumers; innovation; institutional barriers; productivity; service sector.

This paper deals with automation in the Service Sector. Consumers today are more dissatisfied with the services which they "buy" than the products they procure. The Service Sector is defined as well as the technologies of automation. It surveys the spread of automation in the United States as well as the institutional barriers impeding this spread. Automation has provided one of the best means for improving the quality of services and productivity in the Service Sector. A concern today is that people may become the victims rather than the masters of automation. To escape such a fate we must decide what we wish for ourselves and apply automation to achieve our goals.

16320. Wiese, W. L., Younger, S. M., **Atomic oscillator strengths in fusion plasma research,** (Proc. IVth Int. Conf. on Beam-Foil Spectroscopy, Gatlinburg, TN, Sept. 15-19, 1975), Paper in *Beam-Foil Spectroscopy*, I. A. Sellin and D. J. Pegg, Eds., **2,** 951-960 (Plenum Publ. Corp., New York, NY, 1976).

Key words: atomic oscillator strengths; beam-foil spectroscopy; fusion plasma research; plasma radiative losses; sodium isoelectronic sequence; Tokamak plasmas.

In the Tokamak devices used in fusion plasma research, highly ionized heavy metal impurities are observed which have detrimental effects on the plasma behavior, such as strong radiative energy losses. Thus, the radiative properties of impurity species, especially their atomic oscillator strengths, have assumed great importance. An effective approach to obtain these quantities appears to be the extension of theoretical methods to highly ionized species, e.g., by the application of nuclear charge dependent techniques. At some point, however, relativistic effects come into play which are largely unexplored. Another possibility is to utilize the regularities of atomic oscillator strengths along isoelectronic sequences to extrapolate to more highly ionized species. Again, relativistic effects will make these extrapolations uncertain. Thus, some key experimental data are urgently needed. Beam-foil spectroscopy has the potential for acquiring such data, but it will be taxed to its limits. The data needs will be reviewed, and it will be shown that combinations of beam-foil results, theoretical values, and systematic trend studies along isoelectronic sequences may lead to useful data for very highly ionized species.

16321. Schneider, S. J., Jr., **Materials properties determination: Transport properties, phase equilibria and slag properties,** *Proc. NSF-OCR Engineering Workshop on MHD Materials, Cambridge, MA, Nov. 20-22, 1974*, pp. 150-167 (Massachusetts Institute of Technology, Cambridge, MA, 1975).

Key words: diffusion; electrical conductivity; magnetohydrodynamics (MHD); phase equilibria; transport properties; vaporization; viscosity.

The combination of high temperatures and high velocity gases containing reactive chemical species produces a very severe environment within a MHD generator. Containment and operating materials must resist not only erosion through vaporization and corrosion by alkali and slag attack, but also must possess the requisite physical properties necessary for generator operation. The design of a materials device (e.g. electrode) to withstand the rigors of these conditions requires knowledge and proper utilization of the basic physical and chemical properties of candidate materials translated to within the context of an operating engineering system. This paper concentrates on some important aspects of materials behavior and characteristics which are thought to be influential or paramount in ensuring long life and operability of the MHD generator. First of all information on the transport properties viscosity, vaporization, diffusion, and electrical conductivity is necessary to effectively design an electrode-insulator system which will operate satisfactorily over the long term. Viscosity of slags is important to the erosive and corrosive wear of the containment materials as well as to the temperature gradients at interfaces. Vaporization (and condensation) mechanisms will determine the chemical compositions at boundary layers and hence influence the ultimate degradative processes which take place. Diffusion rates of species to and from a given location such as interior layers will dictate the long term stability of these sections. Electrical conductivity of electrodes, insulators and slags and their reaction products is of overriding importance to the operability and performance of the generator. Second the phase equilibria of contacting phases, either solid, liquid or gas, will establish to resulting phase assemblages and hence the "worst case situation." Knowledge of the pertinent phase relations allows incorporation of design features which will delete or minimize degradative reactions. Each of the materials properties are interrelated and must be considered together for proper design and operation of a MHD generator. This paper discusses each of these properties of materials appropriate to clean fuel generators and for coal fuel applications.

16322. Klose, J. Z., **Measurement of atomic uranium lifetimes for isotope separation,** (Proc. SPIE/SPSE Tech. Symp. on Ultra High Power Lasers for Practicable Applications, Reston, VA, Mar. 22-23, 1976), *SPIE 76*, 150-155 (Society of Photo-Optical Instrumentation Engineers, Palos Verdes Estates, CA, 1976).

Key words: atomic beam; delayed coincidence; imprisonment; lifetime; mean life; resonance radiation; transition probability; U I; uranium.

Following a brief discussion of uranium isotope separation using lasers, the delayed coincidence method of measuring atomic mean lives with pulsed electron beams utilized here is described along with the beam source used to supply the free uranium atoms for measurement. Experimental details involved in the lifetime measurement are next discussed followed by the effect of resonance radiation imprisonment on the measured lifetimes. Finally, lifetime measurements involving the 3584.9 Å and 5915.4 Å transitions in natural uranium are described, and the previously reported result of 7.3 ± 1.1 ns for the mean life of the upper level of the 3584.9 Å transition (27886.99 cm^{-1}) is presented.

16323. Unassigned.

16324. Christ, B. W., Swanson, S. R., **Alignment problems in the tensile test,** *J. Test. Eval.* **4,** No. 6, 405-417 (Nov. 1976).

Key words: alignment; stresses; tension tests.

Uniaxial tensile testing is a method used throughout the world to measure the strength and ductility of materials. An important aspect of uniaxial tensile testing which often goes unrecognized is test system alignment. Poor alignment can significantly influence test results at small strains, especially the fracture strengths of materials in a brittle state. The purpose of this review paper is to enable a reader to identify sources of misalignment, recognize the effects of misalignment on tests results, evaluate the extreme surface bending strains and stresses, and become acquainted with some techniques for reducing misalignments to within tolerable limits. Numerous references are made to the literature which describes how misalignment may be influenced by couplings in the loading train and by specimen design. A quantitative assessment of the devices and techniques discussed in this literature is made in those cases where sufficient data have been provided. The literature surveyed indicates that misalignment in carefully designed and precisely machined testing systems ranges between 3 and 15 percent bending. The need for reporting the misalignment at which a given test result is obtained is pointed out.

16325. DeSpain, H. E., Garfinkel, S. B., **Calibration of detectors for argon-41,** *Proc. Noble Gases Symp., Las Vegas, NV, Sept. 24-28, 1973,* pp. 155-159 (1973).

Key words: argon; calibration; detector, radioactive argon; ionization chamber; sodium-22; standard reference materials.

Most nuclear reactors produce argon-41 during their operation. For many, it is the largest single gaseous radioisotope released outside the reactor. It is essential, therefore, to know the concentration of this gas—both in working areas for the protection of reactor personnel and in reactor effluents for environmental protection. For this reason, it was important to develop a rapid and easy method to precisely measure the concentration of argon-41, wherever it may be found.

The radioactivity of an irradiated sample of argon was assayed by comparing it to an NBS Standard Reference Material of sodium (^{22}Na). The argon-41 was then transferred to an ionization chamber, and an accurate calibration of the response of the ion chamber was made. This chamber was subsequently used to calibrate other detectors, including the stack monitor for the NBS 10 MW heavy-water research reactor. The method used does not require an accurate knowledge of the neutron flux density, cross section, nor volume of gas irradiated for the calibrating samples. Also, the activated argon does not have to be transferred to another container before assaying. Furthermore, this method allows for quick and repeated recalibrations and measurements whenever required. The results to date have been excellent.

16326. Mamrak, S. A., **A predictive response time monitor for computer networks,** *Proc. 3d Int. Conf. on Computer Communication, Toronto, Canada, Aug. 3-6, 1976,* pp. 626-630 (1976).

Key words: computer networks; minicomputers; Network Access Machine; network services; response time; response time predictions.

A predictive response time module to assist users of a heterogeneous network of computers is proposed. The network user is able to query this dynamically updated software module to obtain current information relating to the busyness of time sharing systems in the network. In particular, the amount of time required on these systems to run various classes of computing applications is displayed.

The implementation of the module is proposed as an extension of a Network Access Machine (NAM) developed by the Computer Networking Section at the National Bureau of Standards. The NAM is a minicomputer which assists the network user in obtaining network services. The response time module will produce either a narrative description of the general response time characteristics of specified network systems or comparative lists of response times for running short and long FORTRAN, COBOL and BASIC jobs, on those systems.

The feasibility of the design and implementation plan was verified by response time measurement experiments conducted on a DEC System-10. A measure of system busyness called "Percent CPU Null Time" was found to be a satisfactorily accurate parameter on which to base response time predictions for the FORTRAN, COBOL and BASIC jobs mentioned above.

16327. Lyerla, J. R., Jr., VanderHart, D. L., **^{13}C spin-lattice relaxation studies of perfluoroalkanes,** *J. Am. Chem. Soc.* **98,** No. 7, 1697-1700 (Mar. 31, 1976).

Key words: chemical shift; fluoroalkanes; molecular dynamics; NMR; relaxation.

To obtain information on the rigidity of perfluoroalkanes in the liquid state, ^{13}C spin-lattice relaxation times (T_1) and $^{13}C-^{19}F$ nuclear Overhauser enhancements (NOE) of individual carbon atoms in liquid n-C_6F_{14}, n-C_7F_{16}, and n-C_8F_{18} have been measured at 39 °C. Analysis of the relaxation results indicates that the only internal motion occurring on the time scale of overall molecular reorientation is rotation of the CF_3 group. Comparison of these results with n-alkane relaxation data provides evidence for higher intramolecular rotational potential barriers in the perfluoroalkyl chain. In addition to the relaxation results chemical shifts and resonance assignments are reported for the three perfluoroalkanes as well as 1H-n-C_7F_{15}.

16328. Oettinger, F. F., Blackburn, D. L., Rubin, S., **Thermal characterization of power transistors,** *IEEE Trans. Electron Devices* **ED-23,** No. 8, 831-838 (Aug. 1976).

Key words: current crowding; hot spots; reliability; safe operating area limits; second breakdown; semiconductor devices; thermal resistance; transistor, power.

The idealized concept of thermal resistance as applied to power transistors is discussed. This concept must be used with care because two of the basic assumptions made in applying the concept to these devices are not valid. Contrary to these assumptions, it is shown that 1) the junction temperature of a power transistor is never spatially uniform, and 2) no unique value of thermal resistance can be defined for all operating conditions. Also, various electrical methods for measuring the junction temperature (thermal resistance) of power transistors are discussed with the emphasis placed on the emitter-only switching measurement technique, which is the preferred standard method of measurement. In addition, the generation and meaning of forward-biased safe-operating-area (SOA) limits are discussed, and it is shown that because of the presence of current crowding and the associated hotspots, the specified SOA limits often permit devices to be operated at dangerously high junction temperatures. Electrical measurement methods capable of determining the peak juntion temperature as well as determining the onset of current

crowding are described, and it is shown how these methods might be used for the generation of improved SOA limits.

16329. Sibley, E. H., **The development of data-base technology,** *Assoc. Comput. Mach. Comput. Surveys Editorial* **8,** No. 1, 1-5 (Mar. 1976).

Key words: data base; data integration; implementation; modelling; technology; terminology.

Here we attempt an integrated approach to a very disoriented field. Problems abound: differences in terminology, differences in modelling, and differences in implementation confuse the potential user, who is faced with almost unanswerable questions. Such problems are found in any evolving technology, especially when it is associated with a fast developing industry, such as computing; while some appear more philosophical than real, others arise from poor understanding of new concepts. Here we shall try to answer some of the questions and reduce the confusion. But obviously, one issue of Computing Surveys cannot be all encompassing; data technology is a field which already boasts hundreds of articles, and text books by the dozen. Thus this issue confines itself to an explanation of various models of data-base systems, showing their differences and similarities, while trying to relate the models to their implementation in current commercial and experimental systems.

We were faced with one major problem in trying to provide an integrated issue: every model uses its own terminology. We therefore decided to attempt to use both a common terminology and a single example wherever possible. This is by no means a simple task; we must not only define terminology and apply it to descriptions of various models, but also show how these terms differ from those used by others in discussing the same ideas: there is no standard, and we are forced to be arbitrary.

16330. Fry, J. P., Sibley, E. H., **Evolution of data-base management systems,** *Assoc. Comput. Mach. Comput. Surveys* **8,** No. 1, 7-42 (Mar. 1976).

Key words: data base; data-base machines; data-base management; data definition; data dictionary; data independence; data manipulation; data model; distributed data base; generalized processing.

This paper deals with the history and definitions common to data-base technology. It delimits the objectives of data-base management systems, discusses important concepts, and defines terminology for use by other papers in this issue, traces the development of data-base systems methodology, gives a uniform example, and presents some trends and issues.

16331. Mielenz, K. D., **Comments on spectrometry nomenclature,** *Anal. Chem.* **48,** No. 7, 1093-1094 (June 1976).

Key words: analytical chemistry; nomenclature; photochemistry; photometry; physical optics; radiometry; spectrometry; spectroradiometry.

Several inconsistencies in the nomenclatures used in analytical spectrometry and in physical optics are pointed out. Specific proposals are made to correct these inconsistencies.

16332. Stevens, J. G., Travis, J. C., DeVoe, J. R., **Mössbauer spectrometry,** *Anal. Chem.* **44,** No. 5, 384R-406R (Apr. 1972).

Key words: chemical applications; instrumentation; Mössbauer spectrometry; nuclear parameters; recent advances; tables; theory.

A comprehensive review is given of the 1969-70 Mössbauer spectroscopy literature relating to chemistry. The key features of chemical studies are reported in tabular form, and theoretical and instrumental achievements are treated in the textual account. A total of 771 references are cited.

16333. Mielenz, K. D., Mavrodineanu, R., Cehelnik, E. D., **Efficient averaging spheres for visible and ultraviolet wavelengths,** *Appl. Opt.* **14,** No. 8, 1940-1947 (Aug. 1975).

Key words: averaging sphere; diffusing effectiveness; efficiency; fluorescent wavelength converter; photometry; spectrophotometry; ultraviolet; visible.

On the basis of a theoretical analysis that identifies the design criteria for optimization of efficiency, an averaging sphere with a barium-sulfate target was constructed that has an efficiency of 80-90 percent in the visible. In spite of the decreased reflectance of the sphere walls in the uv, this sphere is still 30 percent efficient at 300 nm and, thus, can be used for near-uv work. For applications below 300 nm, a cell containing a fluorescent dye is placed inside the sphere in order to shift the incident radiation into the longer wavelength region in which the reflectance of the sphere walls is higher. The use of this fluorescent wavelength converter, which was designed so that the sphere remains usable in the visible, resulted in a sphere efficiency of about 20 percent in the region between 200 nm and 300 nm and 50 percent in the visible. The averaging properties of these spheres were found to be adequate for high-accuracy photometric measurements.

16334. Kubota, M., Golightly, D. W., Mavrodineanu, R., **A rapid wire-loop method for determination of lead in paint by atomic absorption spectrometry,** *Appl. Spectrosc.* **30,** No. 1, 56-63 (1976).

Key words: atomic absorption; determination; lead; paint; wire loop.

A simple, rapid method is described for the determination of lead in paint. Lead is extracted from paint chips, or liquid paint, into an acidic aqueous solution. Ten microliters of sample solution is transferred onto a platinum-rhodium wire loop, and the solvent is evaporated by placing the loop in a small resistance heater. The loop then is introduced into a premixed acetylene-air flame, and lead absorption at 283.3 nm is measured. Physical and chemical parameters affecting the accuracy and precision of the method are discussed. Accurate determinations of lead are possible for concentrations ranging from 0.1 to 1 μg/10 μl of solution. The wire loop method is adaptable to a simple screening method for analysis of paints in mobile or on-site laboratories.

16335. Lawn, B. R., **A model for the wear of brittle solids under fixed abrasive conditions,** *Wear Short Commun.* **33,** 369-372 (1975).

Key words: abrasion; brittle surfaces; chipping fracture; hardness; wear rate.

An explicit model for the wear of brittle surfaces under fixed abrasive conditions is presented in terms of indentation fracture concepts. The predicted wear rate for glass agrees with that observed experimentally to within an order of magnitude. Some implications concerning the parameters which influence the abrasion process, particularly the hardness, are discussed.

16336. Powell, F. J., **Trends in heating, ventilating and air-conditioning,** *Proc. 5th CIB Congress on Research into Practice. The Challenge of Application, Paris, France, June 1971,* pp. 646-648 (1971).

Key words: air-conditioning; heating.

The rapid growth of science and technology in recent years has improved the means by which man can control his environment, but it has also created a rising tide of expectations on his part for a better quality of environment. The merging of the means and the desire for better environment is one of the strong current trends with respect to the equipment and systems used for heating and cooling of buildings. This paper describes some of the current efforts and future needs,

with special emphasis on the use of a dynamic approach and computers, for promoting this convergence of potential and desire, as a response to the prepared papers on New Trends in Heating and Ventilation for the 5th Congress of CIB.

16337. Cassatt, W. A., Yap, W. T., Reed, W. P., Mills, S. A., **Results of measurements on fine particle standard reference materials at NBS,** *Powder Tech.* **13,** 27-31 (1976).

Key words: fine particle standards; particle concentration; particle counting; particle size; particulates; standard reference materials.

The current efforts at the National Bureau of Standards to produce a standard reference material (SRM) for accurate size and concentration measurements in fine particle technology are discussed. Two batches of latex spheres are being characterized as calibration materials for "flow-through" particle counters. The criteria for selecting these materials, and the choice of the packaging techniques are described. The methods of measuring the size of the particles, which will be furnished in aqueous suspension, are discussed along with the measurement data.

16338. Garbern, D., Kelly, G. E., **Dynamic efficiency of a gas-fired boiler,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II,* Paper C.1, pp. 330-335 (Purdue Res. Indation, Lafayette, IN, 1976).

Key words: dynamic boiler efficiency; efficiency vs cycling rate; efficiency vs heating load; gas-fired boiler.

The effect of cycling rate and part-load operation on the efficiency of a gas-fired, cast iron, hydronic boiler was examined in the laboratory. The boiler studied has an input rating of 300,000 BTU/hr (316,500 KJ/hr). Experimental curves are presented which show how the measured efficiency varied with the rate of cycling at several different heating loads. It was found that the cycling rate had only a slight effect on the part-load efficiency of the gas-fired boiler.

16339. Fong, J. T., Zapas, L. J., **Chemorheology and the mechanical behavior of vulcanized rubbers,** *Trans. Soc. Rheol.* **20:3,** 319-338 (1976).

Key words: anisotropy; chemorheology; degradation; elasticity; finite deformation; incompressible materials; permanent set; polymers; rubbers, viscoelasticity.

The objective of this work is to represent general nonlinear viscoelasticity by a model based on a modified two-network theory. As a basic problem we examine Neubert and Saunders' data (1958) on the permanent set of crosslinked natural rubber samples after heating in a state of pure shear or simple extension. It is evident that the preferred configuration changes with time of heating. Our approach is to associate the preferred configuration with an internal measure of length in an initially isotropic material which becomes anisotropic after heating in a deformed state. Using Ericksen and Rivlin's work (1954) on anisotropic materials and a strain energy function which reduces for isotropic materials to Rivlin and Saunders' function (1951), we show an excellent consistency with the Neubert and Saunders' data. We also show consistency with some more recent data due to Djiauw and Gent (1973).

16340. Cram, S. P., Chesler, S. N., **Coupling of high speed plasma chromatography with gas chromatography,** *J. Chromatogr. Sci.* **11,** 391-401 (Aug. 1973).

Key words: chromatography; coupling of high speed plasma; gas chromatography; high speed plasma; plasma.

A gas chromatograph has been coupled to a new rapid scan (20 msec) plasma chromatograph without the use of a molecular separator. The sensitivity, noise, and signal-to-noise ratio for Freons analyzed on the plasma chromatograph were found to be relatively insensitive to changes in the plasma chromatograph carrier and drift gas flow rates, and a unique mass calibration curve for the E-series Freons is reported. The sensitivity of the plasma chromatograph and GC FIDs are compared for Freons and the utility of the plasma chromatograph in identifying GC effluents and peak fractionation is reported. A comparison is made between gas chromatography/plasma chromatography and GC/MS.

16341. Dragoo, A. L., **Steady thermocapillary convection cells in liquid drops,** *Proc. Int. Colloquium on Drops and Bubbles, Pasadena, CA, Aug. 28-30, 1974,* pp. 208-226 (1974).

Key words: convection; drops; Marangoni effect; surface tension; thermocapillarity.

A nominally spherical drop is used as a model for a theoretical analysis of thermocapillary convection and for estimates of convective flow rates in "levitated" melts at zero-g. Since in practice temperature fields and the resulting convective flow can be more complicated than the simple vertical temperature gradient and the single vortex ring, respectively, the convective flow arising from a general steady-state temperature field is analyzed. Expressions for the components of a steady velocity field are obtained by adapting the analytical method of Miller and Scriven. The vortex rings are illustrated by means of typical streamlines for the simpler, more symmetric temperature fields. The circulation time is introduced as a measure of the rate of circulation in a convection cell and typical values are given for several materials.

16342. Kelnhofer, W. J., Hunt, C. M., Didion, D. A., **Determination of combined air exfiltration and ventilation rates in a nine-story office building,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II, Paper B.4,* pp. 322-328 (Purdue Res. Indation, Lafayette, IN, 1976).

Key words: air infiltration; energy conservation; measurement techniques; ventilation of office buildings.

The sulfur hexaflouride tracer-gas technique, which has been used previously for determining air infiltration rates in residential buildings, was applied to a nine-story office building of modern design. The building has sealed windows with openings only on the first level and on the roof, and is mechanically ventilated with a variable air volume system. Tests were run during the cooling season by introducing the tracer gas into the main trunk of the air supply system and measuring the concentration decay rate in the return air. Infiltration rates were determined with outside air vents open and closed. To check the results, a second independent method was used, which involved direct measurement and calculation of infiltration-rates.

16343. Schaffer, R., **The development of a clinical reference method for glucose in serum,** *Pure Appl. Chem.* **45,** 75-79 (1976).

Key words: clinical reference method; definitive glucose method; glucose in serum; isotope dilution-mass spectrometry; serum glucose.

The progress achieved as of July 1975 on the development of a clinical reference method for glucose is presented; this effort originated as a subcommittee function of the American Association of Clinical Chemists. The hexokinase glucose-6-phosphate dehydrogenase method for determining glucose was selected as the candidate clinical reference method. Its use in all laboratories performing the round-robin tests has provided high precision values. Its accuracy is being evaluated against the results of isotope dilution-mass spectrometry (ID-MS) as the definitive method for glucose.

Work as yet incomplete shows some erratic differences between the ID-MS and the candidate clinical method. More is to be done with ID-MS to ensure the validity of its values before further efforts on the clinical reference method are undertaken.

16344. Hertz, H. S., May, W. E., Chesler, S. N., Gump, B. H., **Analysis of μg/kg (ppb) level hydrocarbons in intertidal zone sediments and water by gas chromatography-mass spectrometry,** *Proc. 23d Annual Conf. on Mass Spectrometry and Allied Topics, Houston, TX, May 25-30, 1975,* pp. 663-665 (1975).

Key words: gas chromatography-mass spectrometry; hydrocarbons; petroleum; water pollution.

The low concentration of hydrocarbons anticipated in pollution baseline studies necessitates the development of analytical techniques sensitive at the sub-microgram/kilogram level. Techniques which involve dynamic headspace sampling and subsequent GC/GC-MS analysis have been developed in this laboratory. Sample components are separated from the matrix in a closed system and concentrated on a porous polymer pre-column, free from large amounts of solvent and ready for GC-MS analysis. Applications of this methodology to the identification of μg/kg level hydrocarbons in a baseline study are discussed.

16345. Currie, L. A., **The measurement of environmental levels of rare gas nuclides and the treatment of very low-level counting data,** *IEEE Trans. Nucl. Sci.* **NS-19,** No. 1, 119-126 (Feb. 1972).

Key words: argon-37; atmospheric mixing; blank corrections; cosmic ray reactions; effectively zero background; environmental radioactivity; low-level counting statistics; radioactive rare gases; reduced activity.

The radioactive isotopes of the rare gases provide unique geophysical and meteorological information concerning the properties and history of our (atmospheric) environment. The extremely low activity levels, however, require very special methods of measurement, experiment design, and data interpretation.

Following an examination of the decay characteristics and atmospheric abundances of Kr and Ar radioisotopes, the question of experiment planning and data interpretation in the "extreme Poisson" (few counts) region is considered. A reduced activity plot is offered as an aid for making rapid evaluations and decisions in this region. The concept of an effectively zero background is illustrated by means of atmospheric ^{37}Ar data.

Finally, the problem of the blank is examined, and the merits and deficiencies of three alternative approaches are discussed, again with special emphasis on the measurement of ^{37}Ar in Nature.

16346. Smith, C. N., Placious, R. C., Mills, R. M., **X-ray systems for bomb disarmament,** *NILECJ-STD-0603.00,* 11 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: bomb disarmament; explosive; x-ray equipment; performance standard, EOD.

Performance requirements and methods of test have been established for x-ray equipment used for bomb disarmament. Requirements are specified which indicate the equipment's suitability for use in the specified application.

16347. Chi, J., **Computer simulation of fossil-fuel-fired boilers,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II, Paper C.2,* pp. 336-346 (Purdue Res. Foundation, Lafayette, IN, 1976).

Key words: boilers; computer simulation; DEPAB (DEsign and Performance Analysis of Boilers); energy saving measures; performance at part load; seasonal efficiency.

After an analytical boiler model is established, which is both an adequate representation of the physical system and capable of reasonably simple mathematical description, governing equations based upon this model are derived. A computer program DEPAB (DEsign and Performance Analysis of Boilers) is then developed to simulate boiler operations. DEPAB is designed to predict the performance of both the gas-fired and oil-fired hydronic boilers. Accuracy of results from computer simulation has been verified by the experimental data on a gas-fired boiler. Verification for the oil-fired boiler will be made in the future, when experimental data become available to the author. Examples are given to illustrate applications of the program to examine quantitatively the effects of design and operating variables on performance and seasonal fuel economy of heating boilers for buildings. It was found that considerable seasonal savings in fuel can often be achieved by performing certain modifications to the existing boilers.

16348. Johnson, C. R., **Normality and the numerical range,** *Linear Algebra and Appl.* **15,** 89-94 (1976).

Key words: eigenvector; normal matrix; numerical range; orthogonal; spectrum.

It is well known that if A is an n by n normal matrix, then the numerical range of A is the convex hull of its spectrum. The converse is valid for $n \leq 4$ but not for larger n. In this spirit a characterization of normal matrices is given only in terms of the numerical range. Also, a characterization is given of matrices for which the numerical range coincides with the convex hull of the spectrum. A key observation is that the eigenvectors corresponding to any eigenvalue occurring on the boundary of the numerical range must be orthogonal to eigenvectors corresponding to all other eigenvalues.

16349. Clifton, J., Frohnsdorff, G., **Polymer-impregnated concretes,** Chapter 12. Special Review in *Cements Research Progress 1975,* pp. 173-196 (American Ceramic Society, Columbus, OH, 1976).

Key words: concrete; concrete-polymer systems; polymers; polymer-impregnated concrete; sulfur-impregnated concrete.

This is a comprehensive literature review on developments in the science and technology of polymer-impregnated concretes, up to December 1975. Altogether 116 references have been reviewed.

16350. Evans, J. M., Jr., **The role of standards in integrated manufacturing systems,** (Proc. Twelfth Annual Meeting and Tech. Conf. of the Numerical Control Society, Washington, DC, May 19-21, 1975), Paper in *Progress through Government Education and Industry Cooperation, NC/CAM EXPO 1975,* pp. 211-217 (Numerical Control Society, Inc., Spring Lake, NJ, 1975).

Key words: automation; computer aided manufacturing systems; computer integrated manufacturing systems; interfaces; motivation for standardization; standards.

Computer controlled integrated manufacturing systems offer increases in labor productivity of up to an order of magnitude or more and cost reductions of factors of 2 or 3 or more. Large user industries are building such systems; however, the cost of special engineering and computer programming and the risk involved preclude medium and small firms from gaining these benefits. The role of standards in constructing integrated systems with components from competitive manufacturers is discussed and the NBS program aimed at the development of those standards is reviewed.

16351. Gerhold, W. F., McCann, J. P., Williamson, W. E., **Report on corrosion of underground telephone cable shielding materials in soil environment after exposure for four years,** *Proc. NACE Conf., Chicago, IL, Mar. 5-9, 1973,* pp. 1-33

(National Association of Corrosion Engineers, Houston, TX 77027, Mar. 1974).

Key words: metal and plastic composites; metal composites, metals; soil corrosion, telephone cable shields; underground corrosion.

Four-year underground corrosion data on the performance at accepted and experimental telephone cable shielding specimens is tabulated and evaluated. The specimens include bare and coated metals or alloys as well as metallic composites. The specimens were uniformly prepared to expose the outer shielding test material to corrosion in a galvanic coupled and uncoupled condition. A replicate of each exposed cable shielding specimen is removed each year from six soil burial sites. The six soil burial sites are representative of a large segment of the various soil conditions existing in the United States.

16352. Gerhold, W. F., McCann, J. P., **Corrosion evaluation of underground telephone cable shielding materials,** (Proc. Int. Corrosion Forum on the Protection and Performance of Materials, Houston, TX, Mar. 22-26, 1976), *Corrosion/76,* Paper No. 31, pp. 31/1-31/62 (1976).

Key words: alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground.

Corrosion data is given on the performance of base and plastic coated metals intended for use as cable shields for buried telephone cable. The materials investigated on specially prepared specimens were buried for periods up to six years in six different soil environments. Metals tested included homogeneous plastic-bonded and metallurgically-bonded laminates. Some specimens were exposed bare (uncoated), while others had plastic coatings or other types of coatings on either one or both sides. Metals studied included aluminum, copper, low carbon steel and stainless steel alloys.

16353. Ogburn, F., **Metrication and the electroplaters,** *Plat. Surf. Finish,* pp. 669, 672-673 (July 1975).

Key words: electroplating industry, metrication of; metal finishing, metric system for; metrication, electrodeposition; metrication, electroplating; metrication, metal finishing; metric system, electroplating industry.

Under the impetus of American industry, the metric system is well on its way to becoming the dominant system of measurement in the United States. Metrication of the electroplating community will be a result of this and it has already begun. For electroplaters metrication will be relatively easy. Some difficulties are anticipated, but these can largely be avoided with appropriate planning by the AES, NAMF, MFSA, and ASTM.

16354. Escalante, E., Gerhold, W. F., **Galvanic coupling of some stressed stainless steels to dissimilar metals underground,** *Am. Soc. Test. Mater. Spec. Tech. Publ. STP* **576,** 81-93 (1976).

Key words: corrosion; galvanic; hydrogen embrittlement; soil; stainless steel; stress; stress-corrosion; underground.

Stainless steels, Type 301 half hard and Type 301 full hard, have been found susceptible to failure by hydrogen embrittlement when stressed as low as 40 percent of their yield strength and cathodically charged above 1 $\mu A/cm^2$ by galvanic coupling to a dissimilar metal in four years of exposure at six underground test sites. However, stainless steels Type 304 and alloys 26Cr-1Mo and 26Cr-6.5Ni were resistant under similar conditions. Failures by stress-corrosion cracking were not observed in any of the materials. Electrochemical measurements made periodically above ground are correlated with the subsequent visual examination of the specimens.

16355. Escalante, E., Gerhold, W. F., **The galvanic coupling of some stainless steels to copper–Underground,** (Proc. Corrosion/75, Toronto, Ontario, Canada, Apr. 14-18, 1975), *Mater. Perform.* **14,** No. 10, 16-20 (Oct. 1975).

Key words: copper; corrosion; galvanic corrosion; soil corrosion; stainless steel; underground corrosion.

On site underground tests at 6 widely differing sites were made of 26Cr-6.5Ni, Type 304 (18Cr-8Ni) and Type 409 (less than 11 Cr ferritic) coupled to commercially pure copper. Galvanic current tests were made over 3 to 4 years and retrieved specimens were examined in the laboratory. When exposure conditions made Cu anodic to the stainless, local corrosion was minimized. Pitting occurred on some stainless specimens at some sites. Type 409 pitted more than other alloys and copper was cathodically protected by stainless in some cases. Chloride-containing, poorly aerated soils (400-15,500 ohm cm) in a tidal marsh caused greatest attack. Cu lost 3 mils and pits formed were 1 to 5 mils deep; 409 perforated and lost 30 percent weight at one site and other alloys at the site pitted to less than 30 mils. Data indicate no increase in attack on stainless steels coupled to Cu over that on uncoupled specimens in same environments.

16356. Boettinger, W. J., Burdette, H. E., Kuriyama, M., Green, R. E., Jr., **Asymmetric crystal topographic camera,** *Rev. Sci. Instrum.* **47,** No. 8, 906-911 (Aug. 1976).

Key words: asymmetric; diffraction; intensifier; topography; x ray.

The practical aspects of asymmetric crystal topography are described. In this technique, asymmetric Bragg diffraction is utilized to obtain a monochromatic and well collimated x-ray beam large enough to cover the entire area of sample crystals. Thus, the recording of diffracted beams from a sample crystal provides topographic images of the entire sample crystal. Advantages of this technique are simplicity (no scanning device), excellent sensitivity to crystal imperfections (strain fields), and versatility. Information is given on the general alignment of the camera, magnification of the x-ray beam width, preparation of the first crystal, and divergence of the beam due to the first crystal. The practical aspects of this topographic system are demonstrated using thick Cu and Ni crystals of various degrees of perfection. An inexpensive image intensifier is also described, which is used routinely to aid in the alignment of sample crystals.

16357. Segransan, P. J., Clark, W. G., Chabret, Y., Carter, G. C., **The Knight shift and nuclear spin relaxation of ^{61}Ni metal in the paramagnet phase,** *J. Phys. F: Metal Phys. Lett. to Ed.* **6,** No. 5, L153-L156 (1976).

Key words: Knight shift; magnetism; nickel; pulsed NMR; spin lattice relaxation.

Pulsed NMR measurements in a 99.54 at% ^{61}Ni enriched sample of Ni metal in the paramagnetic phase are reported for a wide range of temperatures (785-1520 K). The Knight shift ($\mathcal{K}$) follows an expected Curie-Weiss law $\mathcal{K}(T) = \mathcal{K}(\infty) + A_K/(T - T_c)$, where $\mathcal{K}(\infty) = (1.48 \pm 0.05)\%$, $A_k = -(560 \pm 10)\%$K, and $T_c = (662 \pm 10)$K. The d spin hyperfine field is found to be $-(108 \pm 8)$kG per Bohr magneton. The recovery of the magnetization following a comb of saturating pulses is $(150 \pm 50)\mu$s for the entire temperature range.

16358. Schaffer, R., **Calibrator product class standard,** *Proc. of the SAMA Calibrator Product Class Standard Forum and Stability Testing Workshop, Chicago, IL, Mar. 18-19, 1975,* 7 pages (Scientific Apparatus Makers Association, Washington, DC 20036, 1975).

Key words: calibration reference materials; calibrators; clinical control materials; clinical standards; consensus standards; reference materials.

A forum was held on the Product Class Standard for Calibrators. This Product Class Standard is closely derived from a National Committee for Clinical Laboratory Standards standard entitled "Calibration Reference Materials and Control Materials in Clinical Chemistry." The development of the standard was discussed.

16359. Corcoran, C. T., Langhoff, P. W., **Polynomial expansions for spectral densities,** *Chem. Phys. Lett.* **41,** No. 3, 609-614 (Aug. 1, 1976).

Key words: electron scattering; moment theory; photoabsorption/ionization; spectral densities.

Modified moments and polynomial expansions are employed in imaging the spectral densities that arise in electron-scattering and photoionization calculations.

16360. Evans, A. G., Clifton, J. R., Anderson, E., **The fracture mechanics of mortars,** *Cement Concrete Res.* **6,** No. 4, 535-547 (1976).

Key words: acoustical emission; fracture mechanics; mortars; polymer impregnated mortars; slow crack growth.

A fracture mechanics study of plain and polymer impregnated mortars has shown that the (slow and rapid) macrocrack propagation resistance of these materials is not significantly affected by mortar processing variables, such as water/cement ratio and curing time, but is strongly enhanced by polymer impregnation. Acoustic emission measurements have indicated the important role of microcracking in the fracture of both plain and impregnated mortars; with the susceptibility to microcracking being substantially retarded by polymer impregnation.

16361. Slater, J. A., **Data systems and fire casualty information,** *Proc. First Conf. and Workshop on Fire Casualties, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, May 28-29, 1975,* pp. 158-171 (Apr. 1976).

Key words: accident data; data systems; fabric flammability; FFACTS; fire accidents; fire data systems; fire hazards; fires; hazard analysis; NEISS; plastics flammability; product safety.

Four data systems are described in terms of their inputs and outputs. Each contains fire-related information which has been collected from all over the United States and is or will be computerized. All the systems are maintained by Federal Government agencies. The National Electronic Injury Surveillance System (NEISS) was developed by the Consumer Product Safety Commission. Based on a statistical sample of hospitals, NEISS includes data on fire-related injuries from consumer products. The National Fire Prevention and Control Administration is developing a National Fire Data System which will incorporate fire data from many sources such as the National Center for Health Statistics, fire incident reports and a national household fire survey. The Flammable Fabrics Accident Case and Testing System and the Plastics Fire Accident Case and Testing System were developed at the National Bureau of Standards in order to study, in-depth, fabric and plastics fire accidents. Both involve field investigations of fires, preparation of detailed case histories and retrieval, analysis and testing of samples. A possible conceptual framework developed by Bryan for analyzing fire data is briefly discussed.

16362. Lias, S. G., **Charge transfer to hydrogen halide and halogen molecules from atomic and diatomic ions,** *Int. J. Mass Spectrom. Ion Phys.* **20,** 123-137 (1976).

Key words: charge transfer; H-atom transfer reactions; hydrogen halides; ion molecule reactions; ion cyclotron spectrometry; rate coefficients.

The charge transfer from Xe^+, Kr^+, and Ar^+ to HI, HBr, HCl, Br_2, and Cl_2 and from O_2^+ and N_2^+ to HI, HBr, and HCl have been investigated. None of these reactant pairs undergoes a fast charge-transfer reaction. The probability of charge transfer for a given ion-molecule pair depends on the existence of a matching between the recombination energy of the reactant ion and energy level of the product ion. No effect of Franck-Condon factors on the probability of charge transfer could be inferred from these results.

The Kr^+, Ar^+, and N_2^+ ions also undergo the alternate reaction, $M^+ + HX \rightarrow MH^+ + X$, with the hydrogen halides, in competition with charge transfer. Except when charge transfer is favorable, the rate of this reaction is proportional to the reaction exothermicity.

A few preliminary results on the reactions of Xe^{2+}, Kr^{2+}, and Ar^{2+} ions with hydrogen halides and halogens are also reported.

16363. Buehler, M. G., Phillips, W. E., **A study of the gold acceptor in silicon p^+n junction and an n-type MOS capacitor by thermally stimulated current and capacitance measurements,** *Solid-State Electron.* **19,** 777-788 (1976).

Key words: gold-doped silicon; measurement methods; MOS capacitor; p-n junction; semiconductor defects; silicon; thermally stimulated capacitance; thermally stimulated current.

The thermally stimulated current and capacitance responses of a gold doped p^+n junction and n-type MOS capacitor were measured experimentally and modeled theoretically for the case of majority-carrier defect charging. The gold acceptor atoms are initially charged with electrons at low temperatures, and during the heating cycle, excess electrons are released from the gold atoms. The thermally stimulated current response for this phase is similar in both structures and has a distinctive peak-and-valley shape and an emission temperature about 220 K. During the steady-state phase, a current peak occurs in the MOS capacitance response. A physical model was developed and the influence of various parameters on the current and capacitance measurements was quantified. Various analytical schemes are described which allow rapid identification of the gold defect center and rapid computation of its density. A simple and inexpensive apparatus is described which is capable of heating rates as high as 10 K/s.

16364. Garvin, D., Hampson, R. F., Jr., **Evaluated numerical data for the SST and chlorofluorocarbon problems: A case study of how to help the engineer and the modellers,** (Proc. AGARD Conf., Washington, DC, Oct. 20-21, 1976), Paper in *AGARD Conference Preprint* **207** *on Advancement in Retrieval Technology as Related to Information Systems,* pp. 13-1 – 13-6 (National Aeronautics and Space Administration, Attn.: Reports Distribution and Storage Unit, Langley Field, VA 23365, 1976).

Key words: chemical kinetics; data center operation; information analysis center; photochemistry; stratospheric chemistry.

Mathematical simulations (models) of the stratosphere have been a primary tool in the analysis of potential pollution of the stratosphere from high-flying aircraft, rockets and the release of organic chlorine compounds at the surface of the earth. These models require large amounts of numerical data about the meteorology and chemistry. The chemical data comes from laboratory measurements and must be interpreted and made available to the user community in an understandable form and, preferably, as recommended values.

How chemical data were supplied to the Climatic Impact Assessment Program of the U.S. Department of Transportation is described here with emphasis on the role played by the Chemical Kinetics Information Center of the National Bureau of Standards. This included planning, identification of needed measurements and available measurements, determination of the needs of users, evaluation of data, interpretation of results for nonspecialists and distribution of tables of rate data. This type of role is suitable for an information analysis center in any large scale interdisciplinary program.

16365. Scheer, M. D., **Processes for converting coal to clean synthetic fuels and their dependence on catalytic materials,** (Proc. Ceramic Materials in High Temperature Gases on Materials Problems and Research Opportunities in Coal Conversion, Columbus, OH, Apr. 16-18, 1974), Paper in *Materials Problems and Research Opportunities in Coal Conversion* **2,** 300-312 (The Department of Metallurgical Engineering, The Ohio State University, Columbus, OH, 1975).

Key words: aromatic asphaltenes; caking; coal gasification; liquefaction processes.

Coal gasification is the chemical transformation of solid coal into a gas which can be ultimately reacted to produce methane which is free of sulfur compounds and contains little or no carbon monoxide and hydrogen. A typical process begins with the preparation of a coal powder whose particles are surface oxidized with air or oxygen so as to reduce its caking properties and hence prevent the plugging of reactor units.

Liquid fuels synthesized from coal will be needed to fulfill the requirements for these essential and conveniently transportable sources of energy. The technical requirements are numerous; coal must be liquefied; ash, S, N, and O removed; hydrogen produced from water and added to convert the aromatic asphaltenes to simpler aromatic which must then be cracked and reformed to produce acceptable gasolines.

16366. Odell, G. B., Schaffer, R., Simopoulos, A. P., Eds., **Phototherapy in the newborn: An overview,** 196 pages (Printing and Publishing Office, National Academy of Sciences, Washington, DC, 1974).

Key words: bilirubin; brain damage; hyperbilirubinemia; neonatal hyperbilirubinemia; phototherapy.

The book contains selected papers from a symposium held February 12-13, 1973 in Washington under the sponsorship of the Committee on Phototherapy of the Newborn, Assembly of Life Sciences, National Research Council. The papers concern the use of light as a therapeutic modality for hyperbilirubinemia in the newborn infant. Subjects considered are: The Radiometry of Phototherapy, Photooxidation, *In Vitro* Photooxidation Products of Bilirubin, The Photochemistry and Photometabolism of Bilirubin, Studies on the Mechanism of Phototherapy in the Congenitally Jaundiced Rat, Toxicity and Protein Binding of Biliverdin and Other Bile Pigments, Methods for Measurement of the Relative Saturation of Serum Albumin with Bilirubin in the Management of Neonatal Hyperbilirubinemia, Bilirubin-Dependent Brain Damage: Incidence and Indications for Treatment, Immediate and Long-Term Effects of Phototherapy on Preterm Infants, Effects of Light on Man, Circadian Rhythms, Important Considerations in the Clinical Management of Infants with Hyperbilirubinemia.

16367. Quindry, T. L., **Sound sensing units for intrusion alarm systems,** *NILECJ-STD-0308.00,* 22 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, July 1976).

Key words: alarm; audio alarm; burglar alarm; intrusion alarm; intrusion detector; sound sensing; standard.

This standard establishes performance criteria for sound sensing alarms intended for use in protective intrusion systems to monitor for attempts to enter a room or building. These devices cause the initiation of an alarm signal to a police panel, central station, or local audible alarm device. Included are requirements and test methods for performance, electrical properties and materials. The characteristics addressed are those which affect the reliability of the devices with emphasis on those performance characteristics which affect their false alarm susceptibility and its tamper resistance.

16368. Dobbyn, R. C., **Selection guide to hearing protectors for use on firing ranges,** *NILECJ-GUIDE-0101.00,* 24 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Apr. 1976).

Key words: earmuffs; earplugs; gunfire noise; hearing damage; hearing protectors; law enforcement equipment.

This guide discusses the hazard of gunfire-noise-induced hearing damage and the use of hearing protectors to guard against this hazard. Its purpose is to provide the shooter with an appreciation of the seriousness of the problem and a basis for the selection of a suitable hearing protector. Maximum permissible noise exposure levels are discussed in terms of the noise produced by firearms and the several damage-risk criteria which have been proposed. The guide concludes with a listing of currently-available hearing protectors and their noise attenuation properties.

16369. Robertson, E., Fechter, J. V., **Directory of security consultants,** *LESP-RPT-0309.00,* 64 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1975).

Key words: burglary; consultants; crimes of opportunity; directory, (security); investigations; law enforcement; resources; security; shoplifting; theft.

This directory presents brief summaries of the capabilities and past experience of security resources available to assist consumers in solving their security problems. Effective application of information provided by these resources should produce reduced crime rates. Individual listings present a brief digest of the background, past activities and specialization of each resource—based on information provided to this project. Presentations were separated into three categories: private consultants; consultants associated with colleges or universities; and specialized resources—associations, institutes, schools, authors, and publishers or film producers concentrating in the security field. Material is provided for information purposes only and does not constitute endorsement by the Federal government.

16370. Kilmer, R. D., Leasure, W. A., Jr., Corley, D. M., Mathews, D. E., Shoemaker, C. O., Jr., **Truck noise 1-D: Empirical model for predicting in-service truck tire noise levels,** *Report No. DOT-TST-76T-5,* 65 pages (Available from the National Technical Information Service, Springfield, VA 22161, July 1976).

Key words: acoustics; noise measurement; noise (sound); tire noise; transportation noise; truck.

SAE Recommended Practice J57—Sound Level of Highway Truck Tires—specifies a simple, practical noise certification test procedure for tires which results in a single-number rating—maximum A-weighted sound level—of the coast by sound level measured according to prescribed procedures. Such a rating by itself, however, does not allow prediction of in-service noise levels. This report discusses the basic assumptions and necessary input data for a DOT/NBS developed empirical model which utilizes the certification test results to predict in-service noise levels. The usefulness and expected accuracy of the predictive model are shown through a comparison of measured versus predicted maximum A-weighted sound levels for a variety of truck/tire combinations.

16371. Berger, H., Parker, W. L., Lapinski, N. P., Reimann, K. J., **Three-dimensional inspection by thermal-neutron laminagraphy,** *Trans. American Nuclear Society 1976 Annual Meeting, Toronto, Canada, June 14-18, 1976,* pp. 115-116 (1976).

Key words: complex object; laminagraphy; multiple-film; radiographic inspection; thermal neutrons; three-dimensional.

Multiple-film laminagraphy is demonstrated with thermal neutron radiographic inspection of a thick object. Radiographic views from several angular orientations are taken and superimposed to bring a desired image plane into focus. The angular views are obtained from the rotational movement of the object-detector assembly in contrast to the conventional translational source movement. The test object was a simulated EBR-II fast reactor fuel subassembly.

16372. Sengers, J. M. H. L., **Critical exponents at the turn of the century,** *Physica* **82A,** 319-351 (1976).

Key words: coexistence curves; critical exponents; fluid critical point; history; Kamerlingh Onnes collection; surface tension; Van der Waals collection; Verschaffelt.

The notion of a critical exponent was first used by Van der Waals in 1893 for describing the critical behavior of the surface tension. He also noticed in the early 1890's that experimental data on capillarity indicated a nonclassical value for the surface tension exponent. Verschaffelt found that this was due to the fact that the coexistence curve exponent beta was nonclassical. In 1900, he established precise nonclassical values for the exponents beta and delta. Even though from this time onwards the "cubic law" for fluid coexistence curves was accepted, the true implication of Verschaffelt's results, namely the failure of classical theory, was not appreciated. Some reasons for this lack of impact will be given.

16373. Boettinger, W. J., Burdette, H. E., Kuriyama, M., **Application of contrast conditions to dynamical images of immobile dislocations,** *Philos. Mag.* **34,** No. 1, 119-127 (1976).

Key words: contrast conditions; dynamical images; immobile dislocations; Lomer locks; sessile dislocations; x-ray dynamical diffraction; x-ray topography.

In x-ray topography, the Burgers vector of a dislocation is usually determined by finding those diffracting planes for which the image of the dislocation becomes invisible. The conditions $\mathbf{H}\cdot\mathbf{b}=0$ and $\mathbf{H}\cdot\mathbf{b}\times\mathbf{n}=0$ would then be applied to determine the Burgers vector. In this paper, these conditions of invisibility have been applied to a particular pattern of straight line images observed by Borrmann disruption in thick crystals ($\mu L > 15$) using many diffracting planes. It is found that the condition $\mathbf{H}\cdot\mathbf{b}=0$ alone is sufficient to determine that the images are caused by Lomer sessile edge dislocations. Furthermore, it is found that the condition $\mathbf{H}\cdot\mathbf{b}\times\mathbf{n}=0$ was not necessary to predict the invisibility of these images. This fact is attributed to the complexities of image formation by dynamical diffraction in imperfect crystals.

16374. Kulin, G., **Discussion of "sediment transport in smooth fixed bed channels" by P. Novak and C. Nalluri,** *J. Hydraul. Div. Proc. Am. Soc. Civ. Eng.* **102,** HY10, 1601-1602 (Oct. 1976).

Key words: grit; sand transport; sewage sand; sewer self-cleansing.

Design criteria for self-cleansing sewer flow are examined in the light of available experimental results on sand transport in open-channel flow in circular pipes.

16375. Block, S., Piermarini, G., **The diamond cell stimulates high-pressure research,** *Phys. Today,* pp. 44-47, 50-52, 54-55 (Sept. 1976).

Key words: diamond cell; electrical resistance; high pressure; nuclear decay; pressure calibrations; spectroscopy; x-ray diffraction.

This article is a general discussion of the diamond-anvil high pressure cell and includes a description of the instrument and the ruby fluorescence method of measuring pressure. It also discusses some of the important aspects in the development of the cell which ultimately led to the production of megabar pressures. A survey is made of what has been done already in this rapidly expanding area of research and includes a discussion of some new opportunities which show great potential.

16376. Hougen, J. T., **Methane symmetry operations,** Chapter 3 in *International Review of Science, Spectroscopy, Physical Chemistry Series Two,* A. D. Buckingham and D. A. Ramsay, Eds., **3,** 75-125 (Butterworth & Co., Ltd., Boston, MA, 1976).

Key words: energy levels; hyperfine interactions; methane; selection rules; symmetry species; tetrahedral.

This article provides a consistent, pedagogically convenient, and explicit treatment of symmetry properties in the CH_4 molecule, including a unified discussion of the permutation-inversion molecular symmetry group ideas of Longuet-Higgins and the more traditional crystallographic point group symmetry ideas. It attempts initially to discuss symmetry properties associated with the spherical-top point group T_d by drawing on the more familiar symmetry properties associated with the D_{2d} symmetric-top subgroup of T_d. Although three different T_d symmetry classification schemes are widely used at present in the methane literature, strong arguments are presented favoring the present scheme. Illustrative references are included from the various schools of thought on theoretical matters, and from the different schools of recent experimental work on CH_4 vibrational, rotational, and hyperfine energy levels.

16377. Field, B. F., Hesterman, V. W., **Josephson junction based voltage standard,** *Proc. Fifth Cal Poly Measurement Science Conf., San Luis Obispo, CA, Dec. 5-6, 1975,* 5 pages (California Polytechnic State University, San Luis Obispo, CA 93407, 1975).

Key words: cryogenic; Josephson junction; standard cell; voltage reference.

An instrument is described that is designed to calibrate cadmium-sulfate (Weston) standard cells to an accuracy (3 σ) of 1 ppm or better. This instrument can replace the involved procedures, equipment and calibrations presently used to maintain a unit of voltage in many standards laboratories. A Josephson tunnel junction operating at cryogenic temperatures is used as a time-invariant reference for a special potentiometer which directly measures the emf of a standard cell. The instrument is easy to use and requires an infrequent frequency calibration.

16378. Cooper, J. W., **The single electron model in photoionization,** (Lecture delivered at the NATO Advanced Study Institute, Carry-le-Rouet, France, Aug. 31-Sept. 13, 1975), Paper in *Photoionization and Other Probes of Many-Electron Interactions,* F. J. Wuilleumier, Ed., pp. 31-47 (Plenum Press, Inc., New York, NY, 1975).

Key words: Hartree-Fock methods; oscillator strength; photoionization; single electron.

The theory of atomic photoionization is developed in a way to show the connections between single-electron and many-body theories.

16379. Langhoff, P. W., Corcoran, C. T., Sims, J. S., Weinhold, F., Glover, R. M., **Moment-theory investigations of photoabsorption and dispersion profiles in atoms and ions,** *Phys. Rev. A* **14,** No. 3, 1042-1056 (Sept. 1976).

Key words: atomic spectroscopy; dispersion; photoabsorption; refractive index.

Moment-theory methods for the construction of photoabsorption and dispersion profiles from associated dipole spectral moments are described and applied to simple atoms and ions. A previously devised (Stieltjes) moment approach, which provides convergent histogram approximations to absorption and dispersion profiles, is refined and extended to the use of arbitrarily large numbers of spectral moments, and an improved (Tchebycheff) moment approach is introduced which gives profiles that are continuous in the photoionization region and exhibit the δ-function-like behavior associated with discrete transitions at the appropriate frequencies. Recurrence relations for the polynomials orthogonal and quasiorthogonal with respect to the distributions are employed in solving the necessary moment problems involving large numbers of spectral moments. The methods are applied in illustrative calculations of absorption and dispersion profiles in one- and two-electron atoms and ions. In the case of one-electron atomic systems the necessary polynomial recurrence coeffi-

cients are obtained in closed form from the known spectral moments, allowing the construction of distributions which reproduce the known profiles with high accuracy, employing as many as 100 spectral moments. Variational calculations using large basis sets of square-integrable functions, including the special functions required to satisfy sum rules, provide accurate spectral moments for atomic helium and the negative hydrogen ion. A simple moment-extension procedure is devised to interpolate the associated recurrence coefficients to infinite order employing their known asymptotic values. The associated Stieltjes and Tchebycheff approximations to the absorption and dispersion profiles obtained in these cases are in excellent agreement with available measurements and previous accurate calculations employing discrete and continuum wave functions.

16380. Hall, J. L., Lee, S. A., **Interferometric real-time display of cw dye laser wavelength with sub-Doppler accuracy,** *Appl. Phys. Lett.* **29,** No. 6, 367-369 (Sept. 15, 1976).

Key words: interferometer, fringe counting; real-time display.

We describe an automatic fringe-counting interferometer with real-time wavelength readout for cw laser sources. Sub-Doppler absolute wavelength accuracy ($\sim 2\times10^{-7}$) is demonstrated with saturated absorption spectroscopy in neon.

16381. Kahler, R. L., Hillhouse, D. L., Anderson, W. E., **A simple overcurrent protection circuit for a high voltage laboratory,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 2, 161-162 (June 1976).

Key words: high voltage transformer protection; overcurrent; overcurrent protection; solid-state overcurrent protection circuit; transformer; transformer overcurrent protection.

A system for safeguarding a moderate power high-voltage laboratory against transformer overcurrents following insulation failures in test objects is described. It is simple, requiring the construction of only two solid-state control circuits and the modification of a commercially available solid-state contactor. It has been tested successfully with simulated breakdowns at up to 50-kV rms, 60 Hz with a 50-kVA load.

16382. Hartman, A. W., **A step height interferometer with one nanometer resolution,** *Opt. Eng.* **15,** No. 2, 180-183, 363 (Mar.-Apr. 1976).

Key words: interferometer; polarization; step height.

An interferometer is described for the measurement of thin film steps. The instrument is a double-pass polarization interferometer and has a resolution of one nanometer. It is self-contained and features simplicity in construction and operation. Measurements illustrating its performance are given.

16383. Brandon, D. G., Melmed, A. J., **FIM analysis of dislocation core structure,** *J. Micros.* **100,** Pt. 1, 7 pages (Jan. 1974).

Key words: core structure; dislocation core structure; FIM analysis.

A direct colour superposition technique has been used to study two dislocations in W, using He field-ion imaging at 77 K. Limitations due to instrumentation and field-ion microscopy are discussed. A single spiral and a double spiral on (112) W were each dissected, by field evaporation, through three successive atom layers, and apparent core shapes and dimensions were determined. The shapes were irregular with diameters of at most 0·5-2 nm for the single spiral and 0·5-1·7 nm for the double spiral. Observed displacements in the positions of the core regions may be associated with dislocation movement induced by the high electric field needed for the observations.

16384. Misakian, M., Hebner, R. E., Jr., **Kerr coefficients of polychlorinated biphenyls and chlorinated naphthalene,** *J. Appl. Phys.* **47,** No. 9, 4052-4055 (Sept. 1976).

Key words: Aroclor; chlorinated biphenyl; chlorinated naphthalene; electric field measurement; electro-optic; high voltage measurement; Kerr coefficients; Kerr effect; space charge.

The electro-optic Kerr coefficients of two polychlorinated biphenyls and chlorinated naphthalene have been measured to an accuracy of ±7 percent using a comparative technique. Physical properties of the fluids relevant to application in electro-optic devices are discussed.

16385. Goldberg, R. N., **Thermodynamics of hexokinase catalyzed reactions. II. Measurement and calculation of enthalpies of reaction as a function of magnesium ion concentration,** *Biophys. Chem.* **4,** 215-221 (1976).

Key words: adenosine 5′-triphosphate; biochemistry; coupled equilibrium; enzyme catalyzed reactions; glucose; heat measurement; hexokinase; magnesium; metabolic processes; microcalorimetry; thermochemistry; thermodynamics.

Enthalpies of phosphorylation of glucose by adenosine 5′-triphosphate have been measured as a function of concentrations of magnesium chloride in TRIS/TRIS·HCl buffer in the pH range 8.64 to 8.98. These measurements are compared with the results of calculations of these enthalpies that use a coupled equilibrium formalism with equilibrium data and enthalpy values selected from the literature. The experimental results span the range of magnesium ion concentrations 1×10^{-6} to 0.3 mol l^{-1}, and show a total variation in the enthalpy of reaction of almost 10 kJ mol^{-1} with the most exothermic reaction occurring at a magnesium ion concentration of 6.0×10^{-4} mol l^{-1}. The calculated enthalpies of reaction, except for the magnesium ion concentration range 4×10^{-6} to 5×10^{-4} mol l^{-1}, are, within estimated uncertainty intervals (0.8 to 10.2 kJ mol^{-1}), in agreement with the measured values.

16386. Cooper, J. W., Manson, S. T., **Photo-ionization in the soft x-ray range: Angular distributions of photoelectrons and interpretation in terms of subshell structure,** *Phys. Rev.* **177,** No. 1, 157-163 (Jan. 5, 1969).

Key words: angular distribution; photoabsorption; soft x rays; subshell structure.

The problem of determining the individual subshell contributions in atomic photoabsorption is discussed. The general form of the angular distribution of photoelectrons in the soft x-ray range for polarized incident photons is considered. Calculations of the subshell contributions within a central-field model and the angular distribution of electrons from these contributions for photoabsorption in Kr in the energy range 200-1500 eV are presented and found to show good agreement with the experimental results of the preceding paper.

16387. Swanson, K. R., Spijkerman, J. J., **Analysis of thin surface layers by Fe-57 Mössbauer backscattering spectrometry,** *J. Appl. Phys.* **41,** No. 7, 3155-3158 (June 1970).

Key words: backscattering measurements; Fe-57 Mössbauer spectra; Mössbauer spectra.

Fe-57 Mössbauer spectra for extremely thin surface layers (600-3000 Å) were obtained by detecting internal conversion electrons emitted after resonant absorption. The sample was placed inside a proportional counter specially designed for Mössbauer backscattering measurements. Helium-10% methane flowgas was used to detect the conversion electrons. It is estimated from the observed spectra that this technique can be used to obtain Mössbauer backscattering spectra for iron-containing surface layers 50-3000 Å thick. Backscattering spectra for thicker surface layers (0.2-0.5 mil) were obtained by merely changing to an argon-10% methane flow-gas mixture and counting the 6.3-keV internal conversion x rays rather than conversion electrons.

16388. Rutherford, W. M., Evans, J., Currie, L. A., **Isotopic enrichment and pulse shape discrimination for measurement of atmospheric Argon-37,** *Anal. Chem.* **48,** No. 3, 607-612 (Mar. 1976).

Key words: atmospheric mixing; atmospheric radioactivity; cosmic ray reactions; isotopic enrichment; ^{37}Ar.

High sensitivity measurements of cosmic-ray-produced ^{37}Ar from the Southern Hemisphere have been completed with the aid of thermal diffusion isotopic enrichment and low-level proportional counting with rise-time circuitry. Thermal diffusion proved to be an excellent means for increasing the very low natural specific activity of ^{37}Ar. Good enrichment factors (~70) were achieved in a period (~6 days) significantly less than the half-life (35.1 days) of ^{37}Ar. Results for Southern Hemisphere samples confirmed that the measurement process was sufficiently sensitive to quantitatively determine the natural, troposphere levels of ^{37}Ar, but they suggested the possibility of some contamination of the Southern Hemisphere ^{37}Ar from artificial sources.

16389. Shier, D. R., **Iterative methods for determining the k shortest paths in a network,** *Networks* **6,** No. 3, 205-229 (July 1976).

Key words: iterative methods; k best paths; linear equations; network algorithms; networks; shortest paths.

This paper presents and develops an algebraic structure for determining the k shortest paths from a given node to all other nodes of a network. Three new methods for calculating such k shortest path information are examined and compared. These methods are based on a fairly strong analogy which exists between the solution of such network problems and traditional techniques for solving linear equations. On the basis of both theoretical and computational evidence, one of the three methods is seen to offer an extremely effective procedure for finding the k shortest paths from a given node in a network.

16390. Lowe, T. C., **Computer security safeguards for privacy: The technical role of NBS,** *Bull. Am. Soc. Inf. Sci.* **3,** No. 1, 16-18 (Oct. 1976).

Key words: data confidentiality; data integrity; encryption; personal identification; privacy; record identification; risk analysis; security.

The paper describes selected projects under the NBS Computer Security Program that relate to the protection of personal privacy, and has been prepared in the format and style of the American Society for Information Sciences' *Bulletin*. This is ASIS' popular publication, as opposed to the more scholarly *Journal*.

16391. Johnson, C. E., Ogburn, F., **Hardness of heat treated electroless nickel,** *Surf. Technol.* **4,** 161-172 (1976).

Key words: auto-catalytic; auto-catalytic nickel; electroless; electroless nickel, hardness of; nickel; nickel-phosphorus alloy, wear of.

The hardness measurements of electroless nickel-phosphorus deposits are reported for compositions of 2.8-12.6 wt.% phosphorus. The hardness measurements were made on as-plated samples and after heat treatments covering a wide range of time and temperature.

As-plated hardness decreases with increasing phosphorus content up to 7-8 wt.% and then remains constant. After 9 hours at 200 °C, the hardness decreases with increasing phosphorus. Heat treatments at 400 °C and above result in hardnesses that depend on composition, time of heat treatment, and temperature of heat treatment. Qualitatively, the relationship is what one would expect for precipitation hardening.

16392. Heinrich, K. F. J., **Fluorescence excited by the continuum and the accuracy of electron probe microanalysis, (Extended Abstract),** *Proc. 10th Annual Conf. of the Microbeam Analysis Society, Las Vegas, NV, Aug. 11-15, 1975,* pp. 1A-1F (1975).

Key words: accuracy; continuum radiation; electron probe microanalysis; fluorescent excitation.

16393. Grabner, L., **Isoelectronic donor iodine and broad-band photoluminescence in TlBr,** *Phys. Rev. B* **14,** No. 6, 2514-2519 (Sept. 15, 1976).

Key words: isoelectronic systems; TlBr.

Two different experiments on nominally undoped crystals of TlBr (indirect band gap 2.670 eV) are reported: thermal quenching of the emission bands between 2 and 100 K, and the dependence of relative intensity of emission bands on exciting intensity, at 2 K. Both support unexpectedly small binding energies, of ~10 MeV, for electrons and holes to residual impurities. These emit broad (0.25 eV) structureless bands at 1.80, 2.20, and 2.43 eV, and are therefore expected to originate in tightly bound centers. Their origin is known only for the 2.20-eV band, which is due to the recombination of an exciton bound to the isolectronic impurity iodine. Thermal quenching of the emission bands shows two activation energies for the 2.20-eV band. These are identified with a binding energy of 37 MeV for the hole to the iodine, and 2 MeV for that of the electron to the system (iodine-hole). For the 2.43-eV band a single activation energy of 4 MeV is identified with the binding energy of an exciton to an unknown defect. Other isolectronic systems are compared with TlBr:I. Their possible connection with induced infrared absorption is suggested. Finally, the direct edge emission found in TlBr in the vicinity of 3.000 eV is discussed, and found to be anomalous in view of recent results showing its band gap to be indirect.

16394. Page, C. H., **What is weight?,** *Am. J. Phys.* **43,** No. 10, 920-921 (Oct. 1975).

Key words: force; kilogram; mass; pound; weight.

The common use of the term "weight" to denote either a mass or a force is discussed. It is shown that there is no acceptable *precise* definition of weight for moving objects. The conclusion is that a restriction on the use of "weight" to mean only a force that is measurable in certain specific situations is not justified, and, furthermore, would not only be unsuccessful but would hinder general acceptance of the metric system.

16395. Page, C. H., **Ambiguities in the use of unit names,** *Science* **179,** 873-875 (Mar. 2, 1973).

Key words: gyromagnetic ratio; measurement units; physical constants; SI units.

The SI concerns abstract idealized units; actual measurements are made in terms of laboratory standards. Reassignment of the value of a particular standard implies adjustments of published data, but the necessary adjustments are *not* deducible from the SI unit names attached to the data. Experimental determinations of physical constants should be reported in terms of the measurement units and standards actually used.

16396. Morrissey, B. W., Smith, L. E., Stromberg, R. R., Fenstermaker, C. A., **Ellipsometric investigation of the effect of potential on blood protein conformation and adsorbance,** *J. Colloid Interface Sci.* **56,** No. 3, 557-563 (Sept. 1976).

Key words: blood protein adsorption; conformation adsorbed proteins; ellipsometry; surface potential.

The possible relationship between the surface charge of an implant material and intravascular thrombosis has long been explored. In order to characterize the effect of potential on protein-surface interactions, ellipsometric measurements have been carried out *in situ*

to determine the conformation and adsorbance of fibrinogen, γ-globulin, and serum albumin adsorbed on platinum and germanium for a range of imposed potentials.

On platinum at pH 7.4, fibrinogen, γ-globulin, and serum albumin all exhibited a reproducible "onset" potential, at which enhanced adsorption occurred. The adsorbance for all three proteins was unchanged from the rest potential value as the applied potential became more anodic until the onset potential was reached. Desorption, as a result of changes in applied potential, was not observed for any protein studied. The adsorbed conformation of all three proteins changed reversibly at moderately cathodic potentials as indicated, for example, by a sharp increase in extension at −0.2 V/SCE. The extension decreased as the imposed potential became progressively anodic. Germanium was found to be unsuitable for these ellipsometric studies due to etching of the surface by the 0.15 *M* NaCl immersion medium.

16397. Blevin, W. R., Steiner, B., **Redefinition of the candela and the lumen,** *Metrologia* **11,** 97-104 (1975).

Key words: candela; lumen; luminous flux; luminous intensity; photometry; SI basic unit.

It is proposed that the basic photometric unit be redefined so as to provide an exact numerical relationship between it and the SI unit of power, the watt, for a specified monochromatic radiation; and (2) that the unit of luminous intensity, the candela, be replaced as the basic unit by the unit of luminous flux, the lumen. It is claimed that the existing definitions are predominantly the product of early photometric practices that have been superseded. A closer link between photometry and spectroradiometry is now desirable. The proposals would enable photometric values to be derived from spectroradiometric data by exact computation, and would remove the need for a primary standard of light. They would not alter significantly the present magnitudes of the photometric units, nor change the existing relationship between photometry and visual perception. Because the proposed redefinitions are in terms of monochromatic rather than complex radiation, however, they would provide a more convenient basis for the future adoption of new spectral weighting procedures.

16398. Madey, T. E., Czyzewski, J. J., Yates, J. T., Jr., **Ion angular distributions in electron stimulated desorption: Oxygen and CO on W(111),** *Surf. Sci.* **57,** 580-590 (1976).

Key words: carbon monoxide; chemisorption; electron stimulated desorption; ion angular distribution; oxygen; tungsten.

The ion angular distributions resulting from electron stimulated desorption (ESD) of oxygen and carbon monoxide chemisorbed on a tungsten (111) crystal have been determined. The O^+ ions released during ESD of adsorbed oxygen exhibit three-fold symmetric angular distributions in orientational registry with the W(111) substrate. The CO^+ and O^+ ions released during ESD of a monolayer of CO are desorbed normal to the (111) surface. Models for both oxygen and CO adsorption are discussed. The data for CO are consistent with adsorption of CO in "standing up" carbonyl structures in the virgin and α-CO binding states.

16399. Layer, H. P., **High-resolution stepping motor drive,** *Rev. Sci. Instrum.* **47,** No. 4, 480-483 (Apr. 1976).

Key words: digital; drive; electronic; generator; motor; stepping.

A digital sine-cosine stepping motor drive has been constructed which decreases the rotational step size by a factor of 31. This system improves the smoothness and resettability of the motor and retains the conventional slew speed and accuracy.

16400. Johnson, D. R., Pearson, R., Jr., **Microwave region,** Chapter 4.3 in *Methods of Experimental Physics* **13, Spectroscopy,** Part B, D. Williams, Ed., pp. 102-133 (Academic Press, Inc., New York, NY, 1976).

Key words: chemical monitoring and analysis; double resonance; microwave instrumentation; microwave spectroscopy; radio astronomy; short-lived molecules.

The instrumentation and experimental techniques developed for the study of the microwave spectra of gases are critically reviewed, with emphasis on methods capable of wide applicability in the frequency range from 4 to 220 GHz where oscillators producing fundamental power are commercially available. A general purpose spectrometer, incorporating techniques widely used in spectroscopic laboratories, is described as a point of reference for defining the essential characteristics of the basic spectrometer components: a source of MW power, a modulator, an absorption cell, a detector, and a method for measuring frequency. As each is discussed the most widely used instrumentation is compared to selected alternative including new developments which show promise for future applications. Original designs for detector and frequency multiplier-mixer mounts and parallel plate absorption cells are given which, when appropriately scaled to the MW frequency, have been successfully used from 4 to 130 GHz. Spectrometers with special characteristics such as broad-banded scanning, high temperature applications, resonant cavity absorption cells, or submillimeter frequency capabilities are discussed. New developments in the submillimeter region have extended scanning microwave spectroscopy to 1.06 THz. The characteristics which make microwave spectroscopy unique—high sensitivity, specificity, and great versatility—are demonstrated by describing new applications to the study of short-lived molecules, chemical monitoring and radio astronomy.

16401. Fiori, C. E., Myklebust, R. L., Heinrich, K. F. J., Yakowitz, H., **FRAME B: An on-line correction procedure for quantitative electron probe microanalysis with a Si(Li) detector, (Extended Abstract),** *Proc. 10th Annual Conf. of the Microbeam Analysis Society, Las Vegas, NV, Aug. 11-15, 1975,* pp. 20A-20G (1975).

Key words: background correction; continuous radiation; electron microprobe correction procedure; energy-dispersive x-ray spectrometry; lithium-drifted silicon detector.

16402. Pella, P. A., **Generator for producing trace vapor concentrations of 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, and ethylene glycol dinitrate for calibrating explosives vapor detectors,** *Anal. Chem.* **48,** No. 11, 1632-1637 (Sept. 1976).

Key words: calibration device; dinitrotoluene; ethylene glycol dinitrate; explosives; generator; trinitrotoluene; vapors.

A vapor generator was constructed to produce known vapor concentrations of explosives such as 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, and ethylene glycol dinitrate below 1 ppb by volume for calibrating trace explosives vapor detectors. The system is temperature controlled which permits a wide range of equilibrium vapor concentrations to be generated. These vapor concentrations are diluted by single-stage, dynamic, gas blending to obtain concentrations as low as 0.05 ppb. A quantitative gas chromatographic procedure was developed to evaluate this system by measuring the output vapor concentrations. The systematic error was usually within 15 to 20 percent of the values expected for TNT, and within 30 percent for EGDN. The applicability of the system for calibration purposes is demonstrated by performance data obtained with three commercial trace explosives vapor detectors.

16403. Forester, D. W., Abbundi, R., Segnan, R., Sweger, D., **Magnetic hyperfine structure in amorphous $DyFe_2$,** (Proc. 20th Annual AIP Conf. on Magnetism and Magnetic Materials, San Francisco, CA, Dec. 3-6, 1974), Paper in *Magnetism and Magnetic Materials-1974,* C. D. Graham, Jr., G. H. Lander, and J. J. Rhyne,

Eds., No. 24, 115-116 (American Institute of Physics, New York, NY, 1975).

Key words: amorphous; magnetization; metal; Mössbauer; ^{57}Fe; ^{161}Dy.

In this paper we summarize the results of a Mössbauer study of the amorphous rare earth-transition metal (RE-TM) alloy $DyFe_2$ in the magnetically ordered state. Both the ^{57}Fe and ^{161}Dy spectra were investigated as a function of temperature and reveal a broad, though measurable, distribution of Fe hyperfine fields (H_{eff}) and quadrupole splittings (QS). There is a distribution similar in magnitude for the Dy hyperfine fields but the observed quadrupole splittings are narrowly distributed. The temperature variation of the ^{161}Dy spectra indicates a large variation of local exchange splittings at the Dy sites. These results are discussed in terms of a model in which the Dy spins are more strongly coupled to their random-direction anisotropy axes than to the neighboring Fe spins (which also experience a weaker random-direction anisotropy).

16404. Hill, J. J., **A low frequency inductive ratio bridge for platinum resistance thermometry,** (Proc. 5th Symp. on Temperature, Its Measurement and Control in Science and Industry, Washington, DC, June 21-24, 1971), Paper in *Temperature, Its Measurement and Control in Science and Industry*, L. G. Rubin, A. C. Anderson, J. E. Janssen, and R. D. Cutkosky, Eds., **4,** Part 2, 1495-1499 (Instrument Society of America, Pittsburgh, PA, 1972).

Key words: ac bridges; bridges; platinum thermometers; resistance measurements; thermometry; two-stage transformers.

Most of the recently developed ac ratio transformer bridges for platinum resistance thermometry have operated at frequencies of the order of 400 Hz. Due to the fact that the resistance values of the thermometer and the comparison standard resistor at these frequencies may differ substantially from their dc values, doubt has been expressed regarding the correlation of such temperature measurements with those made using traditional dc methods. However, using two-stage transformer techniques, it is now possible to construct ratio transformers to operate at 20 or even 10 Hz with an accuracy of a few parts in 10^8 (equivalent to temperature intervals of few tens of micro degrees) and thus virtually eliminate this objection while still preserving all the advantages of ac methods. Nine-decade adjustable-ratio transformers have been built which are connected in a modified Kelvin Double Bridge circuit. The effective input impedance of the ratio arms is several megohms thus reducing the effect of the connecting leads to extremely small proportions. The paper also considers and discusses the relative advantages of most existing methods for platinum resistance thermometry, the limitations of comparison resistors and the philosophy behind possible future trends and developments.

16405. Alperin, H. A., Cullen, J. R., Clark, A. E., **Magnetic properties of bulk amorphous Tb_xFe_{1-x},** (Proc. 21st Annual AIP Conf. on Magnetism and Magnetic Materials, Philadelphia, PA, Dec. 9-12, 1975), Paper in *Magnetism and Magnetic Materials-1975*, J. J. Becker, G. H. Lander, and J. J. Rhyne, Eds., No. 29, pp. 186-187 (American Institute of Physics, New York, NY, 1976).

Key words: amorphous Tb_xFe_{a-x}; Curie temperatures; magnetization measurement; neutron diffraction.

Magnetization measurements have been made on four bulk samples (compositions $x = 0.018, 0.118, 0.167$ and 0.25) prepared by direct current rapid sputtering. Neutron diffraction measurements show these samples to be amorphous. All four samples are ferrimagnetic; however, the 17 percent sample is almost completely compensated at temperatures below 100K. With decreasing Tb-content, the Curie temperatures fall from a maximum of 405K for $x = 0.25$ to the value of 245K for $x = 0.018$. Anomalously large coercive fields and time dependent magnetizations are present at low temperatures.

16406. Helbig, V., Kelleher, D. E., Wiese, W. L., **Stark-broadening study of neutral nitrogen lines,** *Phys. Rev. A* **14,** No. 3, 1082-1093 (Sept. 1976).

Key words: nitrogen; plasma line boardening; spectral lines; Stark broadening; Stark shifts; Stark widths.

Extensive photoelectric measurements of the plasma-broadened line shapes of 42 neutral nitrogen lines have been carried out with a wall-stabilized arc. The arc current was varied from 20 to 100 A to achieve a variation in the axial electron density from about 5×10^{16} to 1.5×10^{17} cm^{-3}. Most observations were made end-on, and the arc was operated in pure nitrogen as well as argon with a small admixture of nitrogen to avoid self-absorption problems, which mainly arose with the red and near-infrared lines. The electron density was determined from the well-known Stark half-width of the hydrogen H_β line, for which purpose a trace of hydrogen was added to the plasma. Our principal results are as follows: (a) Good agreement with the recent theoretical work by Griem and coworkers has been obtained; (b) consistent with theoretical predictions, ion-broadening effects are not noticeable; (c) the Stark widths and shifts for different lines in a multiplet are identical within the experimental precision (≈3%) as predicted by the theory; and (d) measurements performed over a range of transitions involving different quantum states agree equally well with the theoretical data, indicating that the atomic-structure part of theory is very adequate.

16407. Hall, J. L., Magyar, J. A., **High resolution saturated absorption studies of methane and some methyl-halides,** Chapter 5 in *Topics in Applied Physics* **13,** High-Resolution Laser Spectroscopy, K. Shimoda, Ed., pp. 173-199 (Springer-Verlag, New York, NY, 1976).

Key words: high resolution spectroscopy; methyl halides; optical heterodyne spectroscopy; quadrupole hyperfine interactions; saturated absorption spectroscopy.

We apply the techniques of high resolution saturated absorption spectroscopy to a number of methyl halide transitions near 3.39 μm. Wavenumbers and assignments are given for most lines. A "ladder" of frequency intervals was established with optical heterodyne techniques. Hyperfine structures due to electric quadrupole interactions was carefully studied for one transition in each of the three heavier methyl halides. This analysis gave the shift in the value eqQ due to vibrational excitation as well as information about the magnetic coupling energy. Finally a spectrum of CH_4 is presented which displays a resolving power of 5×10^{10}. This value is believed to be the highest yet employed in coherent spectroscopy.

16408. Brown, P. W., Clifton, J. R., Frohnsdorff, G., Berger, R. L., **The utilization of industrial by-products in blended cements,** (Proc. 5th Mineral Waste Utilization Symposium, Chicago, IL, Apr. 13-14, 1976), Paper in *Proceedings of the Fifth Mineral Waste Utilization Symp.*, pp. 278-284 (ITT Research Institute, Chicago, IL, 1976).

Key words: blast furnace slag; blended cement; fly ash; materials and energy conservation.

Approximately 85 million tons of portland cement are produced annually in the United States. However, less than one million tons of blended cement containing suitable waste or by-product materials, such as fly ash or blast furnace slag, are produced. In view of the potential for by-product utilization and raw materials and energy conservation, the advantages of increased use of blended cement should be considered. The potential for blended cement production and utilization and the advantages and limitations of utilization are discussed. The limitations imposed on the use of blended cements by standards and other factors are discussed. The technical benefits from the use of blended cements are considered.

16409. Brinckman, F. E., Iverson, W. P., Blair, W., **Approaches to**

the study of microbial transformations of metals, *Proc. 3d Int. Biodegradation Symp., Kingston, RI, Aug. 17-23, 1975,* pp. 919-936 (1976).

Key words: detection; flameless atomic spectrophotometry; gas chromatography; graphite furnace; methylation of metals; microbial transformation; speciation; volatile metal compounds.

An approach to the study of microbial transformations of metals existing in trace amounts in the environment is based primarily on the detection and speciation of volatile forms of these metals. Simple qualitative means for surveying the potential of microorganisms for volatilizing metals are described. Identification of transport agents has been accomplished primarily through the use of flameless atomic spectrophotometry coupled with gas chromatography. This technique permits chracterization of volatile metals and organometallic compounds in the nanogram range so that microbial transformations of metals at environmental levels may be monitored. The abiotic transfer of methyl groups from biologically methylated metals to Hg(II) provides a useful tool for the speciation of volatile metal forms suspected of being methylated.

16410. Yakowitz, H., **Present status of quantitative electron probe microanalysis,** *Proc. 6th European Congress on Electron Microscopy, Jerusalem, Israel, Sept. 1976,* pp. 37-40 (Tal International Publishing Co., Jerusalem, Israel, 1976).

Key words: electron probe microanalysis; Monte Carlo calculations; particulates; quantitative analysis; thin films; x rays.

All procedures for performing quantitative x-ray microanalysis require use of a standard of known composition. The analyst measures the relative x-ray intensity ratio between the elements of interest in the specimen and the same element in the standard. Both specimen and standard are measured under identical experimental conditions. The measured relative intensity ratio, often called k, must be accurately determined or else any quantitative analysis scheme will result in the same inaccuracy. Factors which can contribute to inaccuracies in k include the Poisson statistics of the x-ray emission process, x-ray detector coincidence loss (dead time) effects, and background noise arising from continuum radiation. Once the k values have been obtained, they must be corrected for several effects including: the differences in electron scattering and retardation in the specimen and standard, i.e., the so-called atomic number effect, absorption of x-rays generated within the specimen along the direction of the x-ray detector, fluorescence effects and continuum fluorescence effects.

16411. Simmons, J. A., **Microscopic aspects of residual stresses,** *Proc. Workshop on Nondestructive evaluation of Residual Stress, San Antonio, TX, Aug. 13-14, 1975,* pp. 11-17 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, 1976).

Key words: dislocation theory; imperfect continua; internal stress; nondestructive evaluation; residual stress.

This lecture on Microscopic Aspects of Residual Stresses was given to the Air Force Materials Laboratory Workshop on Nondestructive Evaluation of Residual Stress. Residual stress and the more general concept of internal stress are defined and their theory developed using the modern methods of elasticity in imperfect continua.

16412. MacGregor, J. G., Breen, J. E., Pfrang, E. O., **Design of slender concrete columns,** *ACI J.*, pp. 6-28 (Jan. 1970).

Key words: bending moments; building codes; column (supports); frames; long columns; reinforced concrete; slenderness ratio; strength; structural analysis; structural design; ultimate strength.

Offers a proposal for revising the slender column design procedures of the 1963 ACI Code. Proposes the use of a rational second-order structural analysis wherever possible or practical. In place of such an analysis, an approximate design method based on a moment magnifier principle and similar to the procedure used under the AISC Specifications is proposed. An outline of the normal range of variables in column design and a lower limit of applicability is proposed which will eliminate over 90 percent of columns in braced frames and almost half of columns in unbraced frames from consideration as slender columns. Through a series of comparisons with analytical and test results, the accuracy of the approximate design procedure is established.

16413. Lind, M. A., Zalewski, E. F., **Silicon photodetector instabilities in the uv,** *Appl. Opt.* **15,** No. 6, 1377-1378 (June 1976).

Key words: detector; photodiode; silicon; ultraviolet; uniformity of response.

Recent measurements of a group of photovoltaic silicon detectors has revealed instabilities that occur in some silicon photodiodes. We discuss two such instabilities which manifest themselves as an increase in the spatial nonuniformity in the uv and an increase in the spectral responsivity after high level uv irradiation. Typical measurements of two types of silicon detectors are presented.

16414.. Bingham, C. D., Yolken, H. T., Reed, W. P., **Nondestructive assay measurements can be traceable,** *Nucl. Mater. Manage.* **V,** No. II, 32-35 (Summer 1976).

Key words: calibration; measurement; nondestructive assay; nuclear; safeguards; traceability.

The use of nondestructive assay (NDA) techniques for the analysis of Special Nuclear Materials is one of the keystones in the development of safeguards technology. Currently this effort to use NDA is being frustrated because of a lack of "demonstratable traceability." Presented here is a discussion of what traceability means and how it can be achieved. Specifically, traceability means far more than having a series of calibration standards for each individual NDA technique. It means defining the limits of uncertainty for both random and systematic error components of a set of measurements (i.e., precision and accuracy). Realizing this, an approach to these evaluations is suggested. In addition, the authors emphasize that the availability of standards is not holding back the use of NDA.

The use of NDA is actually limited by the poor accuracy (possible systematic error) of many methods and the availability of real calibration standards would only tend to accentuate this point.

Finally, the suggestion is made that calibration standards will only be available when the demonstrated need is limited to a finite number of sets.

16415. Lucatorto, T. B., McIlrath, T. J., **Efficient laser production of a Na^+ ground-state plasma column: Absorption spectroscopy and photoionization measurement of Na^+,** *Phys. Rev. Lett.* **37,** No. 7, 428-431 (Aug. 16, 1976).

Key words: far ultraviolet spectroscopy; ion absorption spectrum; ion photoionization; laser ionization; photoionization resonances; sodium.

We report the first observation of ionization of dense Na vapor by laser radiation. A 1-MW pulsed laser at 589.6 nm produced almost complete ionization of a 10-torr-cm column of Na. Measurements of the Na^+ photoionization cross section, the neonlike series $2s^22p^6 \rightarrow 2s^22p^5ns$ and nd, and several autoionizing resonances of the type $2s^22p^6 \rightarrow 2s2p^6np$ were obtained using a spark source to provide the continuum background for absorption spectroscopy of the ion.

16416. Post, M. A., Iverson, W. P., Campbell, P. G., **Evaluating non-mercurial fungicides,** *Mod. Paint Coat.* **66,** No. 9, 31-38 (Sept. 1976).

Key words: accelerated testing; alkyd paints; environmental

chamber; exterior exposure; latex paints; nonmercurial fungicides.

Nonmercurial fungicides were evaluated for effectiveness in an exterior acrylic latex and in an exterior long oil alkyd paint. Exterior exposure tests were of six months, one year and two years duration at the National Bureau of Standards exposure site. Exterior exposure tests were also carried out at the U.S. Naval Station, Roosevelt Roads, Puerto Rico. Accelerated fungus exposure testing was performed for four and eight weeks in an environmental chamber (a) without prior exterior exposure, (b) after six months, one year and two years exterior exposure, and (c) after exposure in a xenon arc accelerated weathering apparatus. Of the eight nonmercurial fungicides tested for latex paint protection, only one afforded complete fungicidal protection after two years exterior exposure. Two of the six nonmercurial fungicides tested for alkyd paint protection were excellent. One was superior and the other equal to the mercurial fungicide. The mercurial fungicide afforded much better protection for alkyd than latex paints.

16417. Grabec, I., Peterlin, A., **Acoustic emission of a crazing polymer,** *J. Polym. Sci.: Polym. Phys. Edition* **14,** 651-661 (1976).

Key words: acoustic emission; amorphous polymer; crazing; fatigue; Kaiser's effect.

The acoustic emission from a crazing polyvinyltoluene in a tensile and bending experiment is described. Acoustic emission appears as a series of bursts which most likely correspond to the initiation and growth of crazes. The emission intensity is characterized by acoustic activity (pulse rate) measured by the ring-down technique. The average activity increases with strain. During repeated loading the acoustic activity shows a measurable intensity and significant rise only beyond the maximum strain of the former runs. This is equivalent to Kaiser's effect in metals. Acoustic emission during the creep experiment occurs in three characteristic periods. They are characterized as the relaxation, fatigue, and breakdown periods. Visual observations indicate that the relaxation period corresponds to the initiation, and the fatigue period to the growth of crazes. In the breakdown period a macroscopic crack develops and the sample fails.

16418. Penn, D. R., **Comment on "Field emission as a probe of the surface density of states",** *Phys. Rev. B* **14,** No. 2, 849-853 (July 15, 1976).

Key words: field emission; surface density of states; transfer Hamiltonian.

It is shown that the primary contribution to the field-emission current comes from electrons with *total* momentum equal to zero in a direction parallel to the metal surface and that the field-emission current measures the density of states at a point several angstroms from the metal surface. An explicit expression is derived for the error made in using the transfer-Hamiltonian technique to calculate the tunneling probability of an electron through a one-dimensional barrier, and it is pointed out that the error is small in the case of field emission.

16419. Plummer, E. W., Waclawski, B. J., Vorburger, T. V., Kuyatt, C. E., **Photoelectron spectra of adsorbed species on tungsten,** *Prog. Surf. Sci.* **7,** 149-182 (1976).

Key words: adsorption; carbon; carbon monoxide; chemical bonding; chemisorption; density dependent transitions; desorption; dissociative adsorption; electronic states; hydrogen; monolayers; nitrogen; oxygen; photoelectron spectra; relaxation energy; surfaces; tungsten; ultraviolet photoemission; valence band; virgin states; α states; β states.

Photoelectron spectra from W(100) and W(110) for $h\omega = 21.22$ and 16.85 eV were studied as a function of controlled exposure to H_2, N_2, and CO at room temperature, and with subsequent heating. The spectra revealed density-dependent conversions of the β-states of adsorbed hydrogen and carbon monoxide. The α and virgin states of CO appear to be molecular with the α state sequentially filling on top of the β-state. The ordered β-state of CO on W(100) is shown to be dissociatively adsorbed. For W(100) photoelectron spectra for initial states overlapping the tungsten band are very similar for nitrogen and carbon adsorbed in the geometrical configuration indicated by a c(2 × 2) LEED pattern. In contrast, hydrogen and oxygen adsorbed on W(100) in a c(2 × 2) configuration produce different spectra, leading to the speculation that nitrogen and carbon may adsorb in the same site.

16420. Kaufman, V., Sugar, J., **Wavelengths, classifications, and ionization energies in the isoelectronic sequences from Yb II and Yb III through Bi XV and Bi XVI,** *J. Opt. Soc. Am.* **66,** No. 10, 1019-1025 (Oct. 1976).

Key words: bismuth; gold; hafnium; ionization energies; iridium; lead; lutetium; mercury; osmium; platinum; rhenium; tantalum; thallium; tungsten; wavelengths; ytterbium.

Spectral observations are reported for transitions to the ground term and first excited term of the one-electron configurations in the $4f^{14}5p^6nl$ isoelectronic sequence from Yb II through Bi XV. Resonance lines are reported for the isoelectronic sequence Yb III through Bi XVI in which the ground state is $4f^{14}5p^6\ {}^1S_0$ and the upper levels are the $J = 1$ levels of the $4f^{14}5p^6nd$, $4f^{14}5p^5nd$, and $4f^{14}5p^5ns$ configurations. The wavelengths fall in the range 70-3700 Å. The spectra were produced by means of sliding and triggered spark discharges and photographed with 10.7 m normal and grazing incidence spectrographs. The data in the Yb III sequence demonstrate the crossing of binding energies of the $4f$ and $5p$ shells at W VII. Rydberg series terms were found in a sufficient number of cases to provide extrapolation curves through Bi XV and Bi XVI. These data enabled us to calculate ionization energies for each of these ions with an uncertainty of ~1 percent or better.

16421. Gadzuk, J. W., **Screening energies in photoelectron spectroscopy of localized electron levels,** *Phys. Rev. B* **14,** No. 6, 2267-2280 (Sept. 15, 1976).

Key words: adsorption; electron gas; photoemission; relaxation energy.

Screening or polarization energies (often called "extra-atomic relaxation energies") associated with localized-hole creation in photoelectron spectroscopy in or on metals have been calculated. Following the procedure of Hedin and Lundqvist, the screening energy is written in terms of an effective matrix element of a nonlocal random-phase-approximation self-energy between wave functions of the localized-hole state. The relevance of spatial extent of the hole, electron-gas dielectric properties, chemical-bonding effects, and surface effects are examined. Calculations for 1 *s* core and bonding H_2 orbital holes in atoms or molecules which are embedded in and adsorbed on electron-gas surfaces are presented. The interplay between orbital size and host interelectron spacing (as manifested in screening lengths) is emphasized. The relationship between screening energies and classical image potentials in photoelectron spectroscopy of adsorbed atoms and molecules is established. Finally, interpretations of observed photoelectron spectra are discussed in terms of binding energies and relaxation, chemical, and "dipole" potential shifts, and the problem of "proper" referencing is addressed.

16422. Siedle, A. R., Hertz, H. S., **Vaporization of (SN)x and TTF-TCNQ,** *Mater. Res. Bull.* **11,** No. 9, 1185-1189 (1976).

Key words: chemical ionization mass spectrometry; mass spectrometry; sulfur nitride; tetracyanoquinodimethane; tetrasulfur tetranitride; tetrathiafulvalene; vaporization.

The vaporization of (SN)x was studied by electron impact and chemical ionization mass spectrometry. Comparison of the spectra

with those of S_4N_4 suggests that vaporization generates an unstable, acyclic S_4N_4 which subsequently fragments to a cyclic $S_3N_3^+$ and SN^+ ion in the mass spectrometer. Mass spectrometry may be used to analyze (SN)x for S_8 and cage S_4N_4. Vaporization of TTF-TCNQ produced the component donor and acceptor molecules.

16423. Hertz, H. S., May, W. E., Chesler, S. N., Gump, B. H., **Petroleum analysis: Methodology for quantitative and qualitative assessment of oil spill,** *Environ. Sci. Technol.* **10,** No. 9, 900-903 (Sept. 1976).

Key words: gas chromatography; liquid chromatography; oil spill; petroleum; quantitation.

An integrated chromatographic technique for petroleum analysis compatible with long-term studies of oil spills is presented. Dynamic headspace sampling and the complementary analytical techniques of gas chromatography and coupled-column liquid chromatography are utilized for quantitation of petroleum containing samples. Gas chromatography-mass spectrometry is employed for identification of individual components in these samples. Analytical data obtained from a major oil spill are presented and discussed.

16424. Buehler, M. G., Thurber, W. R., **A planar four-probe test structure for measuring bulk resistivity,** *IEEE Trans. Electron Devices ED-23,* No. 8, 968-974 (Aug. 1976).

Key words: bulk resistivity; collector resistivity; four-probe; planar test structure; resistivity; semiconductor characterization; semiconductor device; silicon; square array.

A small planar four-probe test structure for measuring the bulk or collector resistivity of silicon wafers was designed and fabricated with a bipolar transistor process. Analogous to a mechanical square array four-point probe, the planar four-probe structure consists of a large-area base diffusion which is broken at four points through which contact is made to the undiffused collector material. A probe spacing of 2.25 mil (57.2 μm) allows the resistivity of the silicon wafer to be measured with good spatial resolution. A correction factor was derived to obtain the true resistivity from measurements on a wafer with finite thickness and a conducting backside, and it is presented along with the correction factors for other cases. The test device was fabricated in silicon wafers whose resistivities ranged from 0.013 Ω·cm to 12 Ω·cm in *n*-type material and from 0.7 Ω·cm to 30 Ω·cm in *p*-type material. Planar four-probe resistivity values are compared with mechanical four-probe values taken on the same wafers before fabrication, and the results are generally in agreement within ±3 percent.

16425. Reader, J., Acquista, N., **$4s^24p^4$-$4s4p^5$ transitions in Zr VII, Nb VIII, and Mo IX,** *J. Opt. Soc. Am.* **66,** No. 9, 896-899 (Sept. 1976).

Key words: molybdenum; niobium; spectra; ultraviolet; wavelength; zirconium.

Spectra of ionized Zr, Nb, and Mo have been observed in sliding spark discharges at peak currents up to 4000 A on the 10.7 m normal and grazing incidence spectrographs at NBS. From these observations the group of $4s^24p^4$-$4s4p^5$ transitions in Zr VII, Nb VIII, and Mo IX have been identified and measured. The energy parameters obtained from least-squares fits to the resultant energy levels are compared with Hartree-Fock calculations.

16426. Cezairliyan, A., McClure, J. L., Coslovi, L., Righini, F., Rosso, A., **Radiance temperature of tantalum at its melting point,** *High Temp.—High Pressures* **8,** 103-111 (1976).

Key words: emittance; high-speed measurements; high temperature; melting point; pyrometry; radiance temperature; tantalum.

Radiance temperature (at two wavelengths, 653 and 995 nm) of tantalum at its melting point was measured with the use of a subsecond-duration pulse heating technique. Specimens in the form of strips with initially different surface roughnesses were used. The results do not indicate any dependence of radiance temperature (at the melting point) on initial surface or system operational conditions. The average radiance temperature at the melting point of tantalum is 2846 K at 653 nm and 2620 K at 995 nm, with a standard deviation of 1 K at 653 nm and 0.4 K at 995 nm. The total inaccuracy in radiance temperature is estimated to be not more than ±8 K.

16427. Morrissey, B. W., Fenstermaker, C. A., **Conformation of adsorbed γ-globulin and β-lactoglobulin. Effect of surface concentration,** *Trans. Am. Soc. Artif. Intern. Organs* **XXII,** 278-283 (1976).

Key words: conformation adsorbed proteins; ellipsometry; infrared bound fraction; protein adsorption.

The adsorption of clotting factors and proteins on the surface of a synthetic implant can modify both their biological activity and the subsequent interaction of formed cellular elements with the surface. In particular, γ-globulin has been implicated in specific biochemical reactions resulting in platelet adhesion. Infrared bound fraction and ellipsometric measurements have been carried out *in situ* to determine the conformation of adsorbed γ-globulin and β-lactoglobulin as a function of surface concentration.

The fraction of adsorbed carbonyl groups of γ-globulin and β-lactoglobulin decreases significantly as the amount adsorbed increases. Ellipsometric measurements of the extension of adsorbed γ-globulin show that as the number of surface attachments decreases, the thickness of the adsorbed protein film increases. Studies with a cross-linked γ-globulin preparation indicate that the native conformation in solution corresponds to an adsorbed conformation intermediate between those found at the extremes of high and low surface concentration.

These results indicate that adsorbed γ-globulin is rather pliant and that the adsorbed conformation of proteins which are present should be taken into account when describing platelet-surface interactions.

16428. Goldberg, R. N., **Microcalorimetric determination of glucose in reference samples of serum,** *Clin. Chem.* **22,** No. 10, 1685-1691 (1976).

Key words: hexokinase; intermethod comparison.

I report a detailed series of microcalorimetric measurement of glucose concentrations in five reference samples of serum. The method utilized (a) calibration in the actual medium of analysis and (b) a correction for interferences owing to the nonspecificity of the enzyme hexokinase. The microcalorimetric results are compared with the tentative results of analyses obtained by the spectrophotometric hexokinase/glucose-6-phosphate dehydrogenase method and by isotope-dilution mass spectrometry. In most cases, the microcalorimetric results appear to be in agreement with the results obtained by these latter two methods. A discussion of the basis of the microcalorimetric measurements is presented.

16429. Johnson, D. R., Suenram, R. D., Lafferty, W. J., **Laboratory microwave spectrum of cyanamide,** *Astrophys. J.* **208,** No. 1, 245-252 (Aug. 15, 1976).

Key words: interstellar molecules; interstellar laboratory spectra; interstellar line identifications; interstellar molecular processes; interstellar transition probabilities.

Laboratory test frequencies have been obtained for rotational transitions of the cyanamide molecule (NH_2CN) in the ground state and the lowest vibrational (NH_2 inversion) state, extending the measured spectrum of the molecule to 120 GHz. Perturbations resulting from Coriolis-type interactions between the ground and the lowest vibrational state cause many of the observed transitions to deviate significantly from the predictions of a conventional centrifugal distor-

tion-corrected rigid rotor model. Absolute energies and Einstein A coefficients are presented for all measured transitions up to $J = 8$ for both states considered.

16430. Cehelnik, E. D., Mielenz, K. D., **Quantum counter photodetectors: A new design,** *Appl. Opt.* **15,** No. 9, 2259-2263 (Sept. 1976).

Key words: emission anisotropy; fluorescence; photodetectors; polarization; quantum counters; rhodamine B chloride; spectrofluorimetry; total internal reflection.

A new design for quantum counter cells is described that uses total internal reflection to minimize depth-of-penetration and polarization effects. This new cell is compared to a standard 1-cm thick quantum counter cylindrical cell. Solutions of 5 g/liter of rhodamine B chloride in ethylene glycol were used in both cells. The fluorescence emission from the cell was found to be significantly less polarized and also less dependent on excitation wavelength.

16431. Seltzer, S. M., **The response of scintillation detectors to internally induced radioactivity,** *Nucl. Instrum. Methods* **127,** 293-304 (1975).

Key words: background; gamma-ray astronomy; induced radioactivity; Monte Carlo calculation; response; scintillation detector.

Pulse-height distributions produced in NaI and CsI detectors by the decay of certain internally distributed radionuclides have been calculated using a Monte Carlo method. The method traces the possible decays of a radioactive atom, taking into account $\beta^{\pm}$-emission, electron capture, gamma-ray emission, internal-conversion-electron emission, and x-ray or Auger-electron emission following the creation of atomic K-shell vacancies. The scattering, absorption, and escape of gamma-rays, annihilation quanta, and x rays are included. Results are presented for the radio-isotopes ^{22}Na, ^{124}I, ^{124}Sb, ^{125}Sb, ^{123m}Te, and ^{125m}Te to indicate the characteristic features of the pulse-height distributions.

16432. Sharp, K. G., Li, S., Johannesen, R. B., **Perfluoro(alkylsilanes). 3. Fluorine-fluorine coupling constants in perfluoro(alkylsilanes) and related molecules,** *Inorg. Chem. Notes* **15,** No. 9, 2295-2297 (1976).

Key words: coupling constants; fluorine; fluoroalkylsilanes; NMR; relative signs; silicon.

^{19}F NMR spectrometric analyses—including relative signs for most F-F coupling constants have been carried out for the perfluoro(alkylsilanes) $CF_3CF_2SiF_3$, $CF_3SiF_2SiF_3$, $CF_3CF_2CF_2SiF_3$, and $SiF_3CF_2SiF_3$. The latter three compounds have not been previously reported. The signs of J_{FF} values can be put on an absolute basis via self-consistent correlations between the above molecules and related polyfluoroalkanes or alkylsilanes, including the series CF_3CF_2X, CF_2SiF_2X, and SiF_3SiF_3X where X = halogen. An effect not previously recognized is that on substitution of Si for C in molecular fragments of the type FCCF or FCSiF the three bond F-F coupling invariably increases by ca. +6 to +10 Hz in an algebraic sense. Theoretical implications of this effect are discussed.

16433. Pallett, D. S., Pierce, E. T., Toth, D. D., **A small-scale multipurpose reverberation room,** *Appl. Acoust.* **9,** 287-302 (1976).

Key words: acoustic modelling; acoustics; impact noise; noise; reverberation rooms; room acoustics; sound power.

A one-fourth scale model of the large (425 m^3) National Bureau of Standards reverberation room is described. This facility was constructed to carry out acoustical research at relatively low cost in a frequency range two octaves higher than that used in the larger facility. Initial experimental measurements carried out in this facility concern sound power emitted by small sources. The pure tone qualification procedure specified in American National Standard S1.21-1972 "Methods for the Determination of Sound Power Levels of Small Sources in Reverberation Rooms" was carried out using computer control of the experiment. This standard is of particular interest to the international acoustical community since it is technically equivalent to ISO Documents DIS 3741 and DIS 3742. The effect of increased low frequency absorption upon room qualification was tested in the model room. Future research plans to make use of the small-scale reverberation rooms are described.

16434. Snyder, L. E., Hollis, J. M., Ulich, B. L., Lovas, F. J., Johnson, D. R., Buhl, D., **Radio detection of interstellar sulfur dioxide,** *Astrophys. J.* **198,** No. 2, L81-L84 (June 1, 1975).

Key words: interstellar; microwave spectra; molecules; Orion; radio astronomy; sulfur dioxide.

Interstellar sulfur dioxide (SO_2) has been detected in emission from the direction of the Orion Nebula molecular cloud and from Sgr B2. SO_2 is the heaviest interstellar molecule detected to date, and the only nonlinear triatomic molecule which does not contain hydrogen. The remarkable Orion emission profiles suggest that two components are supporting the SO_2 emission: a dense circumstellar-type envelope, which may be in maser emission, and a warm galactic cloud component.

16435. Petree, B., Humphreys, J. C., Lamperti, P. J., Loftus, T. P., Weaver, J. T., **Comparison of cobalt-60 exposure determinations by calorimetry and by ionization chamber techniques,** *Metrologia* **11,** 11-15 (1975).

Key words: calorimetry; cobalt-60; ionization chamber.

The exposure rate computed from calorimeter power measurements is compared to the exposure rate of the same source (1-Ci cobalt-60) determined by means of a graphite cavity ionization chamber. A difference of 0.38 percent was found and is not considered significant compared to the estimated systematic uncertainty (1.3%).

16436. Mangum, B. W., Utton, D. B., **Antiferromagnetic ordering in $ErPO_4$,** (Proc. 20th AIP Conf. on Magnetism and Magnetic Materials, San Francisco, CA, Dec. 3-6, 1974), Paper in *Magnetism and Magnetic Materials,* C. D. Graham, Jr., G. H. Lander, and J. J. Rhyne, Eds., No. 24, pp. 65-66 (American Institute of Physics, New York, NY, 1975).

Key words: antiferromagnetic transition; antiferromagnetism; dipolar interactions; $ErPO_4$; magnetic phase diagram; Néel temperature; spin-flop.

The magnetic susceptibility and dM/dB as a function of field have been measured for $ErPO_4$ from 25 mK to 4.2 K. They show that $ErPO_4$ orders antiferromagnetically with $T_N = 100 \pm 2$ mK with the spins along the tetragonal a-axes. The magnetic phase diagram is presented which includes a spin-flop phase in the basal plane. It is proposed that dipolar interactions may be responsible for the magnetic ordering.

16437. Shumaker, J. B., **Light emitting diode calibrations at NBS,** *Proc. 8th Session Comité Consultatif de Photométrie et Radiométrie, Sèvres, France, Sept. 3-5, 1975,* pp. 95-99 (Bureau International des Poids et Mesures, Pavillon de Breteuil, Sèvres, France, 1976).

Key words: calibration; light emitting diode; spectral irradiance.

A very brief report is given of some aspects of spectral irradiance calibrations of red LEDs at NBS. A typical spectral distribution is given and the treatment of temperature effects is discussed.

16438. Marlowe, D. E., **National measurement study—Microstudy force,** *NCSL Newslett.* **14,** No. 1, 44-45 (Mar. 1974).

Key words: force; NMS.

A brief summary of the National Measurement System Micro-Study of Force is presented.

16439. Davis, R. M., **Implications of privacy legislation on the use of computer technology in business,** *Jurimetrics J.* **17,** No. 1, 95-110 (Fall 1976).

Key words: computer security; information handling; privacy; safeguards for security and privacy; technology for security and privacy.

The National Bureau of Standards has been charged with responsibility for developing guidelines and standards for government compliance with legislation to protect individual privacy. NBS has identified emerging problems in security and privacy and the need for technological developments to provide solutions. Safeguards for security and privacy are not identical. The large number of record systems processing personal records in both the public and private sectors points up the magnitude of the problem of retrofitting these systems for security and privacy safeguards. In many cases, sophisticated systems are not required, and good information practices will be sufficient to meet the requirements. The safeguards differ for each system. There is also a need for auditing techniques to check on the effectiveness of the safeguards put into place. The techniques developed will be useful in preventing computer fraud, assuring functional fidelity and maintaining data integrity during input and processing.

16440. Negas, T., Roth, R. S., Parker, H. S., McDaniel, C. L., Olson, C. D., **Chemical aspects of materials containing cerium oxide,** *Proc. 5th European Conf. on Thermophysical Properties of Solids at High Temperatures, Moscow, Russia, May 18-21, 1976,* pp. 1-13 (1976).

Key words: cerium oxide; magnetohydrodynamics; system K_2O-ZrO_2-cerium oxide; thermal microbalance; x-ray diffraction.

The phase relations in the cerium oxide-ZrO_2 system reinvestigated under oxidizing conditions, in air, and up to 1600 °C using thermal microbalance, conventional ceramic heating and quenching, and x-ray diffraction methods. Additionally, reactions of materials of this system with K_2O (the K_2O-ZrO_2-cerium oxide system) are reported. These data are correlated with analyses of electrode materials tested in the U-O2 MHD facility.

16441. Cetas, T. C., **Temperature measurement in microwave diathermy fields: Principles and probes,** *Proc. Int. Conf. on Cancer Therapy by Hyperthermia and Radiation, Washington, DC, Apr. 28-30, 1975,* pp. 193-203 (American College of Radiology, Chevy Chase, MD, 1976).

Key words: measurement temperature; medicine temperature; microwave diathermy fields; temperature measurement.

Thermometry and medicine have been associated closely for a long time. Physicians contributed to the development of various thermometers, and physiological applications were among the first uses of temperature measurement. For example, body temperature or "blood heat" was used as a reference point for some of the early temperature scales. Even today, when the word "thermometer" is used, the clinical thermometer comes to mind most often.

16442. Krauss, M., Neumann, D. B., **The $^5\Sigma_g^+$ state of N_2,** *Mol. Phys.* **32,** No. 1, 101-112 (1976).

Key words: electronic structure; energy curve; N_2; predissociation; radiative recombination; $^5\Sigma_g^+$.

The electronic structure and energy curves of the $1^5\Sigma_g^+$ and $2^5\Sigma_g^+$ states of N_2 have been analyzed using the multiconfiguration self-consistent-field (MC-SCF) method for calculating the wavefunctions and energies. The *ab initio* model curve for the $1^5\Sigma_g^+$ state obtains an r_e of 1.69 Å and a D_e of 825 cm^{-1}. There is also a barrier with a maximum at 2.21 Å with a height of about 800 cm^{-1} which is a novel feature of this calculation. The potential supports two bound vibrational levels and two shape resonances for $j=0$. The calculated curve differs most from the semiempirical curve of Carroll in having a larger r_e by about 0.14 Å and a well depth smaller by 250 cm^{-1}.

The $^5\Sigma_g^+$ curve is known experimentally to predissociate both the $B^3\Pi_g$ and $a^1\Pi_g$ vibration-rotation levels above the dissociation limit. Conversely, two-body radiative association of two $N(^4S)$ atoms is known to occur through the interaction of the $1^5\Sigma_g^+$ and B and a states. The two-body radiative rates are analyzed in terms of the likely spin-orbit interaction between the $1^5\Sigma_g^+$ and B and a states and the ratio of these rates is calculated under the assumption that the predissociation rate exceeds the radiative in both cases. The ratio of the two-body associative rates k^B/k^a is calculated to be roughly 20 which is to be compared to an experimental ratio of 32.

16443. Ditmars, D. A., **Measurement of the average total decay power of two plutonium heat sources in a Bunsen ice calorimeter,** *Int. J. Appl. Radiat. Isot.* **27,** 469-490 (1976).

Key words: Bunsen ice calorimeter; calorimetric standards; calorimetry; heat standards; phase-change calorimeter; plutonium dioxide; plutonium isotopes; radionuclide calorimetry; radionuclide decay power; standards.

A Bunsen ice calorimeter has been specially adapted for high-precision power measurements on radioactive heat sources. The construction of the apparatus, the principles underlying its operation and the interpretation of the heat data obtained in both static and dynamic experiments are thoroughly described. Dynamic electrical calibration experiments yielded a calibration constant for this calorimeter of 270.56 J/g mercury, with an estimated overall inaccuracy of 0.04 percent. This agreed with the present static calibration constant of 270.59 J/g mercury, with an estimated overall inaccuracy of 0.01 percent, well within the combined estimated limits of overall inaccuracy. The average total decay powers of the radioactive heat sources "1.5 WB" and "0.23 WB," supplied by the Mound Laboratory, have been measured. These powers, referred to 27 November 1974, are, respectively, 1.44936 W with an estimated overall inaccuracy of 0.050 percent and 0.22517 W with an estimated overall inaccuracy of 0.144 percent. These limits represent a linear sum of random error calculated at a 99 percent confidence level and estimated maximum systematic error. The decay powers predicted on the basis of heat-flow calorimetry carried out at the Mound Laboratory both before and after the present investigation are 0.004 percent and 0.12 percent above the present results for the sources "1.5 WB" and "0.23 WB," respectively.

16444. Okabe, H., **Fluorescence quenching of sulfur dioxide by source emission gases,** *Anal. Chem.* **48,** No. 11, 1487-1489 (Sept. 1976).

Key words: emission gas; exhaust; fluorescence; nitric oxide; quenching; sulfur dioxide.

The quenching constants of SO_2 fluorescence excited by a 216-nm deuterium source have been obtained for N_2, O_2, air, and CO_2. They are 0.75 ± 0.09, 2.68 ± 0.09, 1.16 ± 0.01, and 0.74 ± 0.07, respectively, all in units 10^{-3} $torr^{-1}$. The fluorescence signal of SO_2 in simulated stack emission is several percent lower than that in pure N_2. The presence of NO does not interfere with the SO_2 measurement by a fluorescence method.

16445. Evans, A. G., Linzer, M., **High frequency cyclic crack propagation in ceramic materials,** *Int. J. Fract.* **12,** No. 2, 217-222 (Apr. 1976).

Key words: ceramic materials; cyclic crack propagation; high frequency; plasticity.

Techniques and instrumentation for studying high frequency cyclic

crack propagation in ceramic materials are described. Tests performed on a silicate glass show that the cyclic slow crack growth mechanism up to 600 Hz is identical to the quasi-static mechanism. Conversely, a strong cyclic effect on the crack growth rate is observed in a tungsten carbide-cobalt material.

16446. Powell, F. J., **A fresh look at fundamental design parameters,** *Proc. Energy Crisis Regional Conf., Chicago, IL, Sept. 19-21, 1973,* pp. 24-1–24-8 (Capital Development Board, Springfield, IL, 1973).

Key words: buildings; energy conservation; heat transfer.

Two fundamental equations of heat energy transfer in buildings are examined and related to practical design decisions that are made by architects and engineers. Available modern technology that represents an improvement over the simplified fundamental approach is described. An example of the use of modern technology is given together with suggested ways to save energy in heating and cooling applications. Some of the problems of implementation of energy conservation measures in buildings are discussed.

16447. Branstad, M. A., Branstad, D. K., **Computer security applications utilizing minis,** (Proc. 9th Annual IEEE Computer Society International Conf., COMPCON 74, Fall, Washington, DC, Sept. 10-12, 1974), Paper in *Digest of Papers Micros and Minis, Application and Design,* pp. 91-94 (IEEE Computer Society, Washington, DC, 1976).

Key words: computer security; minicomputers.

Protection of data which is stored and processed in computers is evolving as the highest priority requirement on ADP systems today. Minicomputers are playing a large role in the effort to achieve secure computing environments. They are being used as testbeds to determine the efficacy of various theories on how to design a secure system. Minis are being analyzed for their ability to provide external security control for existing large machines. As computers are being connected in networks, the mini may be instrumental in providing security for the network. These computer security applications utilizing minicomputers are outlined in this paper.

16448. Stolz, A., Bender, P. L., Faller, J. E., Silverberg, E. C., Mulholland, J. D., Shelus, P. J., Williams, J. G., Carter, W. E., Currie, D. G., Kaula, W. M., **Earth rotation measured by lunar laser ranging,** *Science* **193,** 997-999 (Sept. 10, 1976).

Key words: earth rotation; geodesy; geodynamics; geophysics; laser distance measurements; moon.

The estimated median accuracy of 194 single-day determinations of the earth's angular position in space is 0.7 millisecond (0.01 arc second). Comparison with classical astronomical results gives agreement to about the expected 2-millisecond uncertainty of the 5-day averages obtained by the Bureau International de L'Heure. Little evidence for very rapid variations in the earth's rotation is present in the data.

16449. Galloway, K. F., Leedy, K. O., Keery, W. J., **Electron-beam-induced currents in simple device structures,** *IEEE Trans. Parts, Hybrids, Packag.* **PHP-12,** No. 3, 231-236 (Sept. 1976).

Key words: device inspection; electron-beam-induced current; microelectronics; *p-n* junctions; scanning electron microscopy; semiconductor devices.

Electron-beam-induced current (EBIC) in semiconductor devices produced by the electron beam of a scanning electron microscope (SEM) can be used to image subsurface device features and to measure certain material parameters. This paper presents a simple method of calculation for estimating the magnitude of EBIC signals. EBIC signals from silicon *p-n* junction diodes are compared with the results of the calculation. The application of EBIC to more complicated device structures is discussed.

16450. Koonce, C. S., **Superconducting transition widths in applied magnetic fields,** *J. Low Temp. Phys.* **24,** Nos. 5/6, 597-610 (Sept. 1976).

Key words: cadmium; condensation energy; demagnetization coefficient; fluctuations; inhomogeneous superconductor; intermediate state; superconducting-normal transition; superconductor; surface energy type I superconductors.

The width of superconducting-normal transitions for inhomogeneous ellipsoidal superconductors in an applied magnetic field is calculated. A simple model is used for the variation in transition temperature with position and the range of this variation is assumed to be larger than the Landau-Ginzburg coherence length. It is found that the decrease in transition width with increasing applied magnetic fields at low fields occurs because the boundaries between superconducting and normal regions begin to be determinded less by the inhomogeneities and more by the loss of condensation energy between domains, and by sample surface effects. At higher fields, the transition width increases with applied field because of the finite demagnetization coefficient.

16451. Hower, P. L., Blackburn, D. L., Oettinger, F. F., Rubin, S., **Stable hot spots and second breakdown in power transistors,** (Proc. 1976 IEEE Power Electronics Specialists Conf., Cleveland, OH, June 8-10, 1976), *PESC 76 Record, 76-CH, 1084-3 AES,* 234-246 (McGregor and Warner, Washington, DC, Oct. 1976).

Key words: base widening; current crowding; hot spots; power transistors; safe operating area; second breakdown; thermal instability.

The mechanism of hot spot formation in transistors is examined from both experimental and theoretical viewpoints. It is shown that after the device becomes thermally unstable the device may restabilize in a hot spot mode of operation. The I_C, V_{CE} thermal instability locus can accurately be predicted assuming the current density is uniform prior to hot spot formation. A new model is proposed which explains why the device may restabilize in a hot spot mode and why devices exhibit "thermal hysteresis." It is also shown using thermal mapping techniques that emitter current crowding exists in the stable hot spot mode. Finally, the experiments support the idea that second breakdown occurs when the current density within the hot spot reaches a critical value.

16452. McCoubrey, A. O., **The national measurement system and specific industrial needs,** *Proc. Fluid Power Testing Symp., Milwaukee, WI, Aug. 11-14, 1975,* pp. 1.1.1.1-1.1.1.8 (Fluid Power Society, Milwaukee, WI, 1975).

Key words: engineering, instrumentation and techniques; fluids; force; hydraulic equipment; mechanical power; noise; pressure; quality control; safety; testing.

When consideration is given to interrelated needs for measurement methods, units, instruments, reference standards, reference data, and traceability, along with the numerous and diverse public and private agencies involved in measurements activity, it becomes important to think in terms of a *unified measurement system,* and to strive toward the rational design of such a system. An effective system will meet the needs of the users in terms of acceptable and accessible central standards, reliable transfer standards, practical levels of accuracy, cost, and unambiguous language for communication.

The Proceedings of the 1974 Fluid Power Testing Symposium suggest that the need for a unified measurement system for the fluid power industry has been well established. There may now be an opportunity to effectively coordinate the resources of industry associations, universities, and user government agencies with those of the National Bureau of Standards.

16453. Manning, R. G., Braun, W., Kurylo, M. J., **The effect of infrared laser excitation on reaction dynamics: O + C_2H_4† and O + OCS†,** *J. Chem. Phys.* **65,** No. 7, 2609-2615 (Oct. 1, 1976).

Key words: carbonyl sulfide; chemical kinetics; ethylene; flash photolysis resonance fluorescence; infrared laser; oxygen atoms; vibrationally excited reactant molecules.

A technique involving flash photolytic production and resonance fluorescence detection of O atoms coupled with cw production of vibrationally excited reactant molecules using a CO_2 laser is described. The method relies on the high sensitivity and precision of the flash photolysis resonance fluorescence technique to compare reaction rates measured with the laser off with those measured with the laser on, thereby assessing any effect of reactant vibrational energy on the dynamics of the chemical reaction. The limiting value of the laser enhancement that can be discerned depends ultimately on two factors: (1) the equilibrium concentration of vibrationally excited reactant that can be experimentally realized (i.e., absorption of laser flux vs deactivation losses), and (2) the magnitude of the activation energy for the thermal reaction. This determines the extent of a purely thermal (heating) effect. We observed little or no effect of vibrational energy in C_2H_4 on the rate of reaction with O atoms. Because of a somewhat higher activation energy, it was considerably more difficult to measure an effect in the O + OCS reaction. Within the limits of detectability, all observations in this system could be attributed to heating effects. A factor of 1.5 increase in the rate constant for O + C_2H_4† over that for O + C_2H_4 and a factor of 3 for O + OCS† over O + OCS would have been detectable in these experiments. The results seem to indicate that there is little or no coupling of vibrational energy to the reaction coordinate leading to activated complexes in these two reaction systems.

16454. Gadzuk, J. W., **Electron spectroscopy of surfaces via field and photoemission,** Paper in *Electronic Structure and Reactivity of Metal Surfaces,* E. G. Derouane and A. A. Lucas, Eds., pp. 341-387 (Plenum Publishing Corp., New York, NY, 1976).

Key words: chemisorption; ESCA; field emission; photoemission; surfaces; x-ray photoemission.

A review and survey of some of the basic physics involved in field and photoemission spectroscopy of surfaces is presented. Special emphasis is placed on the role of spatial coherence in determining the noninteracting electron photoemission characteristics of surfaces. Many-body effects, in particular the static response leading to relaxation energies and the dynamic response resulting in satellite structures are treated and the connection between them is demonstrated.

16455. Klein, M., Haar, L., **Equilibrium compositions and compressibility factors for air in the temperature range 1500 to 13000 kelvin and for densities from 10^{-6} to 10^{3} times standard density,** *AEDC-TR-76-85,* 77 pages (Available from the National Technical Information Service, Springfield, VA 22161, June 1976).

Key words: air; gases; high density; mixtures; thermodynamic properties.

A formalism for computing thermodynamic properties and equilibrium compositions of reacting gas mixtures at high densities is developed. This formalism makes use of the Haar-Shenker version of the augmented hard sphere equation of state. The formalism is used for computing compressibility factors and equilibrium compositions of air in the temperature range 2,000 K-13,000 K for densities from that appropriate to air at standard conditions (0 °C, 1 atmosphere) to densities 1000 times as great. These tables are consistent with the earlier NBS tables which covered the range up to 100 times that density. Some interesting features of the dependence of composition on density are discussed.

16456. Kaldor, A., Woodward, B. W., **Infrared lase monitoring techniques for NO and NO_2,** *AIChE Symp. Ser.* **71,** No. 148, 183-189 (1974).

Key words: apparatus and methods; infrared lasers; magnetic resonance; molecular spectroscopy; NO, NO_2, pollutant detection.

The concentration of NO and NO_2 can be monitored by several different infrared laser devices and techniques. These include laser sources such as a CO laser, tunable diode lasers, tunable spin-flip Raman laser, etc. and detection techniques such as Zeeman magnetic resonance, intracavity absorption, and optoacoustic devices. Sensitivities to the ppb range have been demonstrated. These different methods are discussed and evaluated.

16457. Cook, L. P., Plante, E. R., Negas, T., Roth, R. S., Olson, C. D., **Crystallization and vaporization studies on synthetic coal slag compositions,** *Proc. 15th Symp. on Engineering Aspects of Magnetohydrodynamics, Philadelphia, PA, May 24-25, 1976,* pp. II.4.1-II.4.6 (1976).

Key words: crystallization; magnetohydrodynamics; potassium activity; synthetic coal slags; system K_2O-CaO-Al_2O_3-SiO_2; vaporization.

Insight as to the chemical behavior of coal slags accumulating on the walls of MHD systems can be gained by examining the results of high temperature experiments on K_2O-CaO-Al_2O_3-SiO_2 mixtures. An increase in CaO content may increase a_{K_2O} appreciably for certain compositions. Potassium aluminate – silica solid solutions, some of which are relatively water soluble, occur over a significant range of silica-poor and Ca-rich compositions at 1400 °C.

Two synthetic slags, with compositions falling close to an observed distribution of coal ash analyses, have been studied with the mass spectrometer using the Knudsen effusion technique. One slag having initially 15 wt% CaO yielded a higher K pressure at 10 wt% K_2O than a K_2O-SiO_2 solution containing 30 wt% K_2O. A second slag with relatively high SiO_2 and Al_2O_3 and 13 wt% K_2O gave a K pressure above that of a K_2O-SiO_2 solution with 20 wt% K_2O.

16458. McDonald, D. G., **Josephson junctions as radiation detectors from millihertz to terahertz,** *IEEE J. Quantum Electron.* **QE-10,** No. 9, 776-777 (Sept. 1974).

Key words: cryogenics; infrared; Josephson junctions; lasers; radiation detectors; superconductors.

The early experiments using Josephson junctions as mixers or detectors were at frequencies below a few hundred GHz. Recently we have shown that Josephson junctions can be used as mixers at much higher frequencies, particularly at CO_2 laser frequencies.

16459. Olver, F. W. J., **Uniform asymptotic expansions and singular perturbations,** *SIAM-AMS Proc.* **10,** 105-117 (American Mathematical Society, Providence, RI, 1976).

Key words: boundary-value problem; eigenvalues; parabolic cylinder functions; resonance; rotating disks; singular perturbations; turning-point; viscous flow; Weber's equation.

A brief account is given of an investigation into the asymptotic nature of the solution of the boundary-value problem

$$\epsilon y'' + 2xA(\epsilon,x)y' - A(\epsilon,x)B(\epsilon,x)y = 0,\ y(a) = l,\ y(b) = m,$$

as $\epsilon \to 0$, where $A(\epsilon,x)$ and $B(\epsilon,x)$ are continuous real functions of ϵ and x, $a < 0$, $b > 0$, and $A(\epsilon,x)$ is nonzero in $[a,b]$. Particular attention is paid to the problem of resonance, which arises when the limiting form of the solution exhibits an unusual lack of decay (in the case $A(\epsilon,x) < 0$), or an unusual rate of growth (in the case $A(\epsilon,x) > 0$). By application of a recent theory of differential equations with coalescing turning points sufficient conditions for resonance are established, both with and without the assumption that $A(\epsilon,x)$ and $B(\epsilon,x)$ are analytic functions of ϵ and x.

Fuller details will be published elsewhere.

16460. Yates, J. T., Jr., Klein, R., Madey, T. E., **Adsorption of molecular nitrogen by the W(110) plane,** *Surface Sci.* **58,** 469-478 (1976).

Key words: adsorption; nitrogen; physical adsorption; tungsten; work function.

Characteristics of the adsorption of nitrogen on the (110) plane of tungsten were determined by thermal desorption and work function measurements. The low temperatue γ-N_2 state desorbs with first order kinetics and an activation energy of 6 kcal mole^{-1}. The absence of isotope mixing between $^{14}N_2$ and $^{15}N_2$ demonstrates γ-N_2 is adsorbed molecularly. Monolayer coverage shows a decrease of 0.19 eV in work function. A Topping model plot indicates the layer is immobile at 123 K.

16461. Wyatt, W. T., Jr., Lozier, D. W., Orser, D. J., **A portable extended precision arithmetic package and library with Fortran precompiler,** *ACM Trans. Math. Software* **2,** No. 3, 209-231 (Sept. 1976).

Key words: elementary function evaluation; extended precision arithmetic; floating point arithmetic; Fortran extended data types; Fortran precompiler.

A set of ANS Fortran subroutines, developed by W. T. Wyatt, which incorporates computer-independent algorithms for performing arithmetic on arbitrary length, extended precision, floating point, real, or complex numbers in any user-designated computation base from 2 to 16 is described. Also included is a library of the Fortran intrinsic and external (mathematical) functions, as well as routines for type conversion, base conversion, input/output, and other operations. Analysis and testing, by D. W. Lozier, of the arithmetic and library software to locate and eliminate errors and to determine approximate accuracy limits is described. Finally, a precompiler, written in Fortran by D. J. Orser, which translates a Fortran program containing two extended precision data types (SUPER PRECISION and SUPER COMPLEX) into an ordinary Fortran program that uses subroutine calls to the software to carry out the extended precision operations is described. The software is intended to furnish working scientists who are not specialists in computer science a ready means of computing in extended precision.

16462. Weber, L. A., **Dielectric constant data and the derived Clausius-Mossotti function for compressed gaseous and liquid ethane,** *J. Chem. Phys.* **65,** No. 1, 446-449 (July 1, 1976).

Key words: Clausius-Mossotti function; dielectric constant; equation of state (PVT); ethane.

Measurements are presented for the dielectric constant of ethane in the saturated liquid and compressed fluid states at temperatures between 95 and 323 K. Pressures ranged up to 390 bar. The data, which have an estimated uncertainty of 0.01 percent, are combined with accurate density data from several sources to produce the Clausius-Mossotti function over a wide range of temperature and density. An analytical expression of the Clausius-Mossotti function is given, and the consistency of the available density data is discussed.

16463. Andrews, J. R., **Impulse generator spectrum amplitude measurement techniques,** *CPEM Digest*, pp. 23-24 (1976).

Key words: calibration; Fourier transform; impulse generator; pulse measurement; spectrum; spectrum amplitude.

This paper discusses the various techniques that have been used to calibrate impulse generators and to measure spectrum amplitude. The techniques included are (1) standard transmission line, (2) harmonic measurement, (3) energy measurement, (4) sum and difference correlation radiometer, (5) Dicke type radiometer, (6) video pulse, MIL. Std. 462, (7) spectrum analyzer, (8) standard pulse comparison, and (9) time domain measurement with Fourier transformation computation. Advantages and disadvantages of each technique are discussed. A summary of experiments comparing the various techniques is included. The NBS measurement service for calibrating impulse generators is described.

16464. Baird, R. C., **Methods of calibrating microwave hazard meters,** *Proc. Int. Symp. on Biologic Effects and Health Hazards of Microwave Radiation, Warsaw, Poland, Oct. 15-18, 1973*, pp. 228-236 (Polish Medical Publ., Warsaw, Poland, 1974).

Key words: microwave hazard meters; microwave radiation.

Accurate and reliable measurements of microwave radiation are required for hazard surveys, leakage detection, testing of products for compliance with regulations, and for determining exposure levels in experiments designed to investigate the biologic effects of microwave radiation. Accurate calibration of the instruments used for these measurements is essential for safety reasons and to provide a basis for comparison of the experimental results of various laboratories.

16465. Birmingham, B. W., Smith, C. N., **A survey of large scale applications of superconductivity in the U.S.,** *Cryogenics* **16,** No. 2, 59-71 (Feb. 1976).

Key words: cryogenics; CTR; electric power; energy storage; generators; instrumentation; MHD; superconductivity.

This survey provides a general overview of the kind and amount of research being done in the U.S. on large-scale applications of superconductivity. It covers about $30 million worth of research and development on systems and devices, and excludes programs on superconducting phenomena or basic studies of properties of materials unless they are part of an applications program. It covers the categories of electric power systems (generation, transmission, and storage); high energy physics; and instrumental-industrial-medical applications. Data were gathered through personal contact and letters to the researchers involved, and include funding and manpower levels where possible.

16466. Carroll, J. J., Melmed, A. J., **Field ion microscopy of zirconium,** *Surface Sci.* **58,** No. 2, 601-604 (Aug. 1976).

Key words: field-ion microscopy; zirconium.

Zirconium was successfully imaged in the field ion microscope using neon ions and mixtures of helium and neon ions at specimen temperatures of about 30K. Micrographs obtained after zirconium was exposed to hydrogen imaging conditions showed features that may indicate the early stage development of cracks, mostly along the $\{11\bar{2}0\}-\{11\bar{2}2\}$ zone. Crack defects were confined to at least the topmost 2-5 layers.

16467. Carroll, J. J., Melmed, A. J., **Optical constants of $(11\bar{2}0)$ ruthenium in the visible region,** *J. Opt. Soc. Am.* **66,** No. 10, 1050-1051 (Oct. 1976).

Key words: ellipsometry; optical constants; ruthenium.

Optical constants are reported for $(11\bar{2}0)$ ruthenium measured ellipsometrically in the visible spectrum under ultrahigh vacuum conditions. The results are compared to literature values.

16468. Clough, R. B., **Rational basis and new methods for proportional limit, machine stiffness, critical stress intensity, and crack velocity measurements,** (Proc. 78th Annual Meeting American Society for Testing and Materials, Montreal, Canada, June 22-27, 1975), *Am. Soc. Testing Mater. Spec. Tech. Publ. 608, Recent Developments in Mechanical Testing*, pp. 20-44 (1976).

Key words: crack propagation; determination of stress; measurement; mechanical tests; plastic deformation; proportional limit.

This paper is a summary of some new measurement techniques

that have been developed recently at the National Bureau of Standards for measurement of proportional limit of elasticity, machine stiffness, critical stress intensity, and crack velocity. These seemingly unrelated measurements all result from the rational basis of a single type of equation relating specimen and machine kinetics. In a regime of linear elasticity, the concept of a limit beyond which the specimen elastic gage length displacement is no longer proportional to load is referred to as proportional limit if the gage length begins to exhibit plastic deformation, and is referred to in a precracked specimen as critical stress intensity if the crack begins to extend in length. Multiaxial plastic yielding is also discussed. Machine stiffness and crack velocity are other measurements which can be obtained through the specimen-machine equation. The relationship of the new stiffness measurement to the International Standards Organization (ISO) proposed method and advantages of the new method are discussed. Methods of measuring stiffness in constant load rate and constant strain rate tests are outlined. A method of measuring the proportional limit or critical stress intensity which does not use a displacement gage of any type is also given; this should prove useful in hostile environments. Other related topics discussed include loading transients and rate sensitivity.

16469. Crawford, M. L., **Experimental evaluation of the radiation characteristics of dipole sources enclosed in a TEM transmission cell,** *CPEM Digest*, pp. 57-59 (1976).

Key words: measurements; radiated emission; radiation resistance; TEM cells.

This paper describes measurements to verify theoretical formulation of the changes in the radiation resistance of electronic equipment enclosed inside a special type shielded enclosure, a rectangular TEM cell. The measurements were made, assuming the device under test (DUT) could be modeled by dipole sources, using a monopole antenna mounted at various locations inside a typical cell. The predicted radiated power from the monopole antenna mounted inside the cell was within ± 2 dB of the energy coupled to the cell's output ports. These results are contained in the paper and give credibility to the ability to relate such measurements to free space radiation conditions.

16470. Crawford, M. L., **Calibration of broadbeam antennas using planar near-field measurements,** *CPEM Digest*, pp. 53-56 (1976).

Key words: broadbeam antennas; planar near field measurements.

This paper describes techniques for improving and extending planar near field (PNF) measurements for use in calibrating broadbeam antennas (gain ≥ 3 dB). This application requires minimizing errors associated with the PFN formulations: specifically, the assumptions that 1) all significant near fields associated with the test antenna fall within the measurement scan area and 2) that multiple reflections between test antenna, probe, and their surroundings are negligible. The techniques discussed include: 1) optimizing the scan parameters (e.g., size of scan area, data point spacing, and separation distance between the test antenna and measure plane); 2) simulating measurements taken over an extended, enlarged, scan area; 3) minimizing multipath error; and 4) use of data deletion and extrapolation to obtain the test antenna's on-axis gain calibration. The paper also contains results of measurements made using a typical broadbeam antenna. These results include comparisons made between a far field pattern obtained using PNF scanning and using a conventional far field range.

16471. Day, G. W., Hamilton, C. A., Gruzensky, P. M., Phelan, R. J., Jr., **Performance and characteristics of polyvinylidene fluoride pyroelectric detectors,** (Proc. IEEE Symp. on Application of Ferroelectrics, Albuquerque, NM, June 9-11, 1975), *Ferroelectrics* **11,** 99-102 (1976).

Key words: infrared detectors; polymers; pyroelectrics; radiometry.

Pyroelectric detectors based on the polymer film polyvinylidene fluoride should be recognized as attractive choices for applications where a high detectivity coupled with a broad spectral response and a large area are required. Devices with a 1 cm^2 area typically have a detectivity of $10^9\ f^{1/2}$ cm $Hz^{1/2}/W$ where f is the frequency in Hz. Fabrication may be directly from commercially available film or with some additional processing. Several instruments incorporating these detectors have been developed to solve certain radiometric measurement problems.

16472. Day, G. W., Hamilton, C. A., Pyatt, K. W., **Spectral reference detector for the visible to 12-μm region; convenient, spectrally flat,** *Appl. Opt.* **15,** No. 7, 1865-1868 (July 1976).

Key words: detector; infrared; pyroelectric; spectral response.

A convenient spectral reference detector for the visible to 12-μm region has been developed. The device consists of a large area PVF_2 pyroelectric detector enclosed in a hemispherical light trap. Based on theoretical and experimental evaluations, the detector response is independent of wavelength to ± 1 percent over this spectral range.

16473. Domen, S. R., Lamperti, P. J., **Comparisons of calorimetric and ionometric measurements in graphite irradiated with electrons from 15 to 50 MeV,** *Med. Phys.* **3,** No. 5, 294-301 (Sept.-Oct. 1976).

Key words: absorbed dose; calorimeter; electrons; heat defect in graphite.

Extensive experimental comparisons of calorimetric and ionometric measurements have been made that cover a broader range of electron energies and depths in graphite than previously reported. Electron beams of 15, 20, 25, 30, 40, and 50 MeV were used. Calorimetric absorbed-dose measurements and ionometric specific-charge measurements in air were compared in graphite at depths from 1 to 51 g/cm^2. The medium was irradiated with uncollimated electron beams produced by scattering after passing through a 0.1-g/cm^2 aluminum vacuum window, various thicknesses of lead foils, and air. The variation in the quotient of the two measurements was studied as a function of lead-foil thickness, depth in the medium, beam energy, foil-to-detector distance, and off-axis distance. These studies permitted the measurements to be corrected and compared with theoretical calculations that assume a broad medium irradiated with broad, parallel, monoenergetic electron beams. The overall experimental uncertainty is estimated to be 1 percent. The results are generally in good agreement with theoretical and experimental results of other investigators. The calorimeter received close to 1 Mrad during preliminary measurements and from 1 to 2 Mrad during the measurements reported. The results showed no detectable heat defect in graphite after prolonged periods of exposing the calorimeter to air at atmospheric pressure.

16474. Ekin, J. W., **Effect of stress on the critical current of Nb_3Sn multifilamentary composite wire,** *Appl. Phys. Lett.* **29,** No. 3, 216-219 (Aug. 1, 1976).

Key words: critical currents; magnets; magnet wire; Nb_3Sn; Nb_3Sn magnets; Nb_3Sn multifilamentary wires; strain; stress; superconducting magnets.

A critical-current study of flexible Nb_3Sn multifilamentary composite wires has been conducted at 4 K in magnetic fields to 90 kOe (7.2×10^6 A/m) while the wire is subjected to high mechanical stresses. The results show that at stresses above $1\text{-}2 \times 10^8$ Pa (strains of 0.1-0.2%) the critical current is significantly degraded, with the magnitude of the reduction dependent on reinforcement techniques used in the wire's construction. The effect increases with magnetic field and results in the introduction of significant resistance at cur-

rent levels well below the zero-stress critical current. Design considerations for the use of Nb_3Sn wires in the high-stress environments of large-scale superconducting magnets are discussed.

16475. Engen, G. F., **Measurement of complex microwave circuit parameters using only power detectors,** *CPEM Digest*, p. 171 (1976).

Key words: automatic network analyzer; microwave; microwave measurement; six-port.

Although straightforward in principle, the extension of existing designs for automatic network analyzers to the higher microwave frequencies is difficult in the current state-of-the-art. What appears to be needed is a basically different approach to the microwave detection problem. This is provided by the so-called "six-port" techniques, which eliminate the need for frequency conversion, local oscillators, phase detectors, etc. Recent theoretical studies have provided new insights into the basic concept and lead to "five-port" configurations which require three instead of four amplitude detectors. Of particular interest is the useful measurement dynamic range of 50-60 dB corresponding to an intrinsic dynamic range required in the amplitude detectors of a nominal 20 dB or less.

16476. Estin, A. J., **Scattering parameters of SMA coaxial connector pairs,** *CPEM Digest*, pp. 110-111 (1976).

Key words: coaxial connectors; connectors; RF connectors; SMA connectors.

A technique is described for making insertion loss and reflection measurements on SMA connectors mounted on solid-dielectric coaxial line. Results are given for measurements of $|S_{11}|$ and $|S_{21}|$ of eight test pairs over the frequency range of 4 to 12 GHz.

16477. Gans, W. L., **Present capabilities of the NBS automatic pulse measurement system,** *CPEM Digest*, pp. 25-26 (1976).

Key words: automated measurement; pulse; rise time; sampling oscilloscope; spectrum amplitude; time domain; transient.

In 1972, NBS began development of an Automatic Pulse Measurement System (APMS) consisting essentially of a minicomputer-controlled wideband sampling oscilloscope. The objective of the work was to produce a fast, general purpose transient waveform acquisition and processing instrument covering the frequency range dc-18 GHz. The purpose of this paper is to report the highlights of work done on the APMS from early 1975 to present.

The measurement applications of the APMS now consist of both publicly offered calibration services and inhouse experimental measurements. In the first category, calibration services are available for the following physical parameters: a. Impulse generator spectrum amplitude; b. Wideband coaxial attenuation/gain; c. Low pass filter risetime; d. Pulse generator risetime.

Still in the experimental stage are measurements involving reflection coefficient and impedance, group delay, pulse distortion, and wideband antenna characteristics. In addition, the APMS is quite often used for theoretical modeling and model/experiment comparison and verification.

16478. Ginsberg, D. M., Harris, R. E., Dynes, R. C., **Strong-coupling correction to the low-frequency electrical conductivity of superconductors and Josephson junctions,** *Phys. Rev. B* **14,** No. 3, 990-992 (Aug. 1, 1976).

Key words: electron tunneling; electronic devices; far infrared; Josephson effect; strong electron-phonon coupling; superconductivity.

Values of the strong-coupling correction to the low-frequency local-limit conductivity of a number of superconductors are given. These values also describe the strong-coupling correction to the critical current of a Josephson tunnel junction. The correction is given for indium, amorphous gallium, β-phase gallium, amorphous bismuth, $Pb_{0.8}Bi_{0.2}$, $Pb_{0.7}Bi_{0.3}$, amorphous $Pb_{0.45}Bi_{0.55}$, $Tl_{0.9}Bi_{0.1}$, $Pb_{0.8}Tl_{0.2}$, and previously published values are listed for tin, lead, mercury thallium, and indium-thallium alloys. It is shown that there is a simple empirical relation between these values and the effective electron-electron coupling parameter $(\lambda - \mu^*)$.

16479. Unassigned.

16480. Greer, S. C., **Coexistence curves at liquid-liquid critical points: Ising exponents and extended scaling,** *Phys. Rev. A* **14,** No. 5, 1770-1780 (Nov. 1976).

Key words: binary mixture; coexistence curve; critical phenomena; density; isobutyric acid; magnetic densimeter; phase equilibria, carbon disulfide, nitromethane; water.

New measurements have been made of coexisting mass densities of isobutyric acid and water with a precision of 20 ppm and within 3.5 °C of the critical temperature. The measurements were made using a single sample of composition very close to critical. It is found that the coexistence curve is more symmetric in terms of the difference in volume fraction ($\Delta\phi$) of coexisting phases than in terms of the difference in mass density. The difference $\Delta\phi$ is well fitted for $\epsilon = (T_c - T)/T_c < 0.006$ by the expression $\Delta\phi = B\epsilon^\beta$, where $B = 1.071 \pm 0.023$ and $\beta = 0.328 \pm 0.004$. (Uncertainties are given as 3 times the standard deviation.) A new analysis has been made of the recent data of Gopal *et al.* on the difference in volume fraction of coexisting densities of carbon disulfide and nitromethane. For this system, $\Delta\phi$ can be fitted for $\epsilon < 0.2$ by an extended scaling expression suggested by Wegner's work, $\Delta\phi = B\epsilon^\beta + B_1\epsilon^{\beta+\Delta_2} + B_2\epsilon^{\beta+2\Delta_2}$. The exponent Δ_2 is fixed at 0.5; the fit gives $\beta = 0.316 \pm 0.008$, $B = 1.63 \pm 0.09$, $B_1 = 0.77 \pm 0.31$, and $B_2 = -2.43 \pm 0.40$. This work suggests that liquid-liquid critical phenomena are consistent with the functional forms obtained from renormalization-group calculations and with asymptotic exponents which are like those presently calculated for the Ising model. The range of asymptotic behavior seems to be larger for a liquid-liquid critical point than for a liquid-gas critical point.

16481. Hammond, G. A., Brown, W. B., Yolken, H. T., **National program of measurements and standards for safeguarding nuclear materials,** (Proc. 17th Annual Meeting Institute of Nuclear Materials Management, Inc., Seattle, WA, June 22-24, 1976), Paper in *Nuclear Materials Management* **V,** No. III, 351-360 (1976).

Key words: fuel; materials accountability; measurements; nuclear; safeguards; standards.

A national measurement and standards program is described which is coordinated essentially by the Nuclear Regulatory Commission, the National Bureau of Standards and the Energy Research and Development Administration. Efforts and progress are outlined as related to assuring that timely, accurate measurements at reasonable cost are available to the nuclear community. The results of this combined effort show that programs are underway to keep abreast of the present measurement needs for nuclear materials safeguards, and that projected work is consistent with a growing U.S. nuclear industry.

16482. Hanley, H. J. M., **Comment on "Citation analysis: A new tool for science administrators",** *Science News and Comment* **188,** No. 4193, 1064 (June 1975).

Key words: citation index.

Comment on "News and Comment" item, entitled "Citation Analysis: A New Tool for Science Administrators," appearing in *Science*, **188,** 4187, p. 429, May 2, 1975.

16483. Hanley, H. J. M., Cohen, E. G. D., **Analysis of the transport coefficients for simple dense fluids: The diffusion and bulk viscosity coefficients,** *Physica* **83A,** 215-232 (1976).

Key words: argon; bulk viscosity; density expansion; methane; modified Enskog theory; molecular correlations; nitrogen; sound absorption.

The analysis of transport coefficients based on the modified Enskog theory (MET), discussed in a previous publication, has been extended to include the self-diffusion coefficient *(D)* and the bulk viscosity coefficient (η_r). Specifically, calculated values according to the MET are compared with experiment over the range for which data are available. Fluids considered are argon, nitrogen and methane. Agreement between theory and experiment for densities less than about twice the critical density (ρ_c) is generally within about 10 percent. However, much of the data was taken at densities well in excess of $2\rho_c$ in which case agreement is still not unsatisfactory. Deviations exceeding 10 percent between theoretical and experimental self-diffusion coefficients were observed for densities in the approximate range $0.9 \leq \rho/\rho_c \leq 2.0$. It is possible that these deviations are due to long range correlated molecular motions which are not present in the MET. The sound absorption is also briefly considered. Finally, the behavior of η_r and D at low densities is discussed.

16484. Hanley, H. J. M., Sengers, J. V., Ely, J. F., **On estimating thermal conductivity coefficients in the critical region of gases,** *Proc. 14th Int. Conf. Thermal Conductivity, Storrs, CT, June 2-4, 1975,* Paper R-960, pp. 383-407 (Plenum Publ. Corp., New York, NY, 1976).

Key words: correlation length; critical point; gas-liquid; nonspherical molecules; Ornstein-Zernike theory; thermal conductivity.

The thermal conductivity of a fluid exhibits a pronounced anomalous increase in a large range of densities and temperatures around the gas-liquid critical point. In this paper we discuss an attempt to estimate the thermal conductivity in the critical region of fluids from a knowledge of the equilibrium properties and the regular behavior of the transport properties outside the critical region.

16485. Harris, R. E., **Intrinsic response time of a Josephson tunnel junction,** *Phys. Rev. B* **13,** No. 9, 3818-3821 (May 1, 1976).

Key words: electronics devices; high speed devices; Josephson effect; superconducting devices; superconductivity; tunneling.

The microscopic theory of the Josephson effect is reformulated in the time domain. The four terms in the usual theory are seen to be necessary consequences of intrinsic junction delays. The tunneling current flowing in response to a voltage pulse is shown to rise in a time $\hbar/2\Delta$ and undergo damped energy-gap oscillations, before approaching the expected supercurrent. The theory provides a technique for calculating junction behavior when connected to an arbitrary circuit.

16486. Harris, R. E., Dynes, R. C., Ginsberg, D. M., **Strong-coupling correction to the jump in the quasiparticle current of a superconducting tunnel junction,** *Phys. Rev. B* **14,** No. 3, 993-995 (Aug. 1, 1976).

Key words: electronic devices; electron tunneling; Josephson effect; strong electron-phonon coupling; superconductivity.

Calculated values of the strong-coupling correction to the jump in the quasiparticle current of superconductor-insulator-superconductor tunnel junctions are given for a number of elements, amorphous materials, and alloys. It is shown that there is a simple empirical relation between the size of jump in the quasiparticle current and the effective electron-electron coupling parameter $(\lambda - \mu^*)$.

16487. Hellwig, H., Allan, D. W., Jarvis, S., Jr., Glaze, D. J., **The realization of the second,** (Proc. Fifth Int. Conf. on Atomic Masses and Fundamental Constants (AMCO-5), Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants,* J. H. Sanders and A. H. Wapstra, Eds., pp. 330-336 (Plenum Publ. Corp., New York, NY, 1975).

Key words: atomic beams; atomic clock; atomic time; cesium beam tube; definition of the second; frequency accuracy; international atomic time; primary frequency standard.

We report realizations of the unit of time with an accuracy approaching 1×10^{-13} using our two primary cesium beam standards. Quantitative values are given for the requirements on operating parameters of such devices in order to assure high frequency stability. Principal design limitations and fundamental approaches to overcome them are discussed. The concept of a servo which maintains accuracy is advanced which would allow primary standards to operate continuously as clocks without loss in their evaluated accuracy.

16488. Hellwig, H., Allan, D. W., Walls, F. L., **Time and frequency,** (Proc. Fifth Int. Conf. on Atomic Masses and Fundamental Constants (AMCO-5), Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants,* J. H. Sanders and A. H. Wapstra, Eds., pp. 305-311 (Plenum Publ. Corp., New York, NY, 1975).

Key words: clocks; frequency accuracy; frequency stability; frequency standards; infrared frequency multiplication; noise; time scale; time standards.

A comparison of the accuracy and stability performance of precise frequency standards is given. It is shown that measurement systems exist which comfortably allow the full characterization of these standards. The importance of spectrally pure oscillators for frequency synthesis into the infrared region is discussed quantitatively. The problem of absolute accuracy in timekeeping is reviewed.

16489. Hellwig, H., Wainwright, A. E., **A portable rubidium clock for precision time transport,** *Proc. 7th Annual Precise Time and Time Interval (PTTI) Planning Meeting, Washington, DC, Dec. 2-4, 1975,* pp. 143-159 (Goddard Space Flight Center, Greenbelt, MD, 1976).

Key words: atomic clocks; frequency stability; portable clocks; rubidium frequency standard; time comparison.

Based on a commercially available rubidium standard the National Bureau of Standards (NBS) developed a portable rubidium clock. Technical modifications which reduce the sensitivity against temperature, magnetic environment, and barometric changes allow stabilities in the 10^{-12} range under typical clock transport conditions. Under laboratory conditions the clock shows a best stability of 3 parts in 10^{14}. Clock packages based on sealed lead-acid batteries featuring a total weight of 21 kg and 18 hours battery operation were tested; an improved clock package was realized using silver-zinc batteries with 11 kg weight and 28 hours battery operation. Report of several clock trips to the U.S. Naval Observatory and of one clock trip each to the Bureau International de l'Heure in Paris and to the Hewlett-Packard Company in Santa Clara, California are reported. Time transport precisions of .02 μs have been obtained. Special aspects of the clock modifications and the operating characteristics are discussed, as well as an optimal use of the data of a clock roundtrip.

16490. Hoer, C. A., Roe, K. C., Allred, C. M., **Measuring and minimizing diode detector nonlinearity,** *CPEM Digest,* pp. 108-109 (1976).

Key words: detectors; diodes; linearity; square-law.

This paper describes a technique for measuring the linearity of amplitude detectors in general, and for measuring the deviation from square-law, E, of point-contact diode detectors in particular. A general mathematical model is given for determining the rf input power as a function of the detector output voltage. For point-contact diodes it is shown how to choose the video load resistance to minimize E, as well as how to calculate and correct for E.

16491. Holste, J. C., Lawless, W. N., Samara, G. A., **Dielectric properties of KH_2PO_4, $BaTiO_3$, $PbZr_{0.65}Ti_{0.35}O_3$ and TlCl between 0.015 and 10 K,** (Proc. IEEE Symp. on Application of Ferroelectrics, Albuquerque, NM, June 9-11, 1975), *Ferroelectrics* **11,** 337-340 (1976).

Key words: barium titanate; dielectric properties; ferroelectrics; KDP; PZT 65/35; thallium chloride; very low temperatures.

The small-signal ac permittivities (ϵ) of single crystal samples of KDP, $BaTiO_3$, and TlCl, and of a ceramic sample of PZT 65/35 have been measured as a function of temperature between 0.015 and 10 K. For KDP and PZT 65/35, ϵ increases essentially linearly with temperature in this range, with $d \ln \epsilon/dT = 0.95 \pm 0.15 \times 10^{-3}$ K^{-1} and $1.81 \pm 0.02 \times 10^{-3}$ K^{-1}, respectively. For $BaTiO_3$ linear behavior is observed only between 1.5 and 4.5 K, with $d \ln \epsilon/dT = 9.4 \times 10^{-4}$ K^{-1}. PZT 65/35 exhibits positive deviation from this apparent linear behavior between 0.1 and 1.5 K, while $BaTiO_3$ shows a negative deviation in this range. Both PZT 65/35 and $BaTiO_3$ have a minimum in ϵ below 0.1 K and an associated change in the dielectric loss factor that depends on the frequency and amplitude of the ac signal. No temperature dependence of ϵ was observed below 3 K for TlCl. Potential applications of these materials at low temperatures are discussed.

16492. Howe, D. A., **Precise frequency dissemination using the 19-kHz pilot tone on stereo FM radio stations,** *IEEE Trans. Broadcast.* **BC-20,** No. 1, 17-20 (Mar. 1974).

Key words: frequency modulation; modulation index; multipath; path delay; phase vs. time; σ vs. τ, 19 kHz pilot.

A continuous 19-kHz pilot tone is included as part of the modulation format of stereo FM broadcast radio stations. An experiment was performed which measures the stability of the received pilot in urban rural environments. A mathematical analysis is presented of the phase stability of the received pilot as a function of multipath. It shows that phase changes will exist dependent upon a reflected radio signal's phase lag, relative amplitude, and the modulation index. Data are presented which indicate: 1) phase versus time of the pilot at the National Bureau of Standards (NBS) laboratory using a directional yagi and a vertical whip; 2) Allan variance measurements of σ versus τ using a directional yagi; and 3) the day-to-day phase delay of the pilot at five urban locations and three rural locations using a vertical whip. With 5 min of averaging time, the delay of the pilot at five urban sites was reproducible to within 2 μs each day over a five-day period. Delay was reproducible to within 0.8 μs at three urban sites.

16493. Howell, B. F., Margolis, S., Schaffer, R., **Detection of inhibitors in reduced nicotinamide adenine dinucleotide by kinetic methods,** *Clin. Chem.* **22,** No. 10, 1648-1654 (1976).

Key words: Michaelis constants for NADH and LDH-5; LDH-1.

Methods are described for detection of lactate dehydrogenase (LDH) inhibitors in preparations of reduced nicotinamide adenine dinucleotide. They are (a) comparison of values by kinetic methods with those measured for highly purified NADH and (b) examination of Lineweaver-Burk plots. Chromatographic inhomogeneities are correlated with deviant values for the kinetic constants of NADH preparations. Lineweaver-Burk plots that curve upward at the high concentrations or have a larger or smaller than normal slope may indicate the presence of inhibitor. As determined in bicarbonate buffer (0.11 mol/liter, pH 7.9) by use of 0.600 mmol/liter pyruvate and NADH freshly separated from impurities by chromatography on diethyl-aminoethyl-cellulose, the K_m (apparent) of NADH at 25 °C has the value 8.11 ± 0.71 μmol/liter (SD, n = 28) with LDH-1 (pig heart, 2.48 ± 0.05 U per milliliter of reaction mixture, or 41.3 ± 0.8 nmol/liter per second). Under similar conditions, the K_m (apparent) of NADH has the value of 8.57 ± 1.58 mol/liter (SD, n = 21) with LDH-5 (pig muscle, 1.77 ± 0.03 U/ml of reaction mixture), or 29.4 ± 0.6 nmol/liter per second). At infinite substrate concentrations with the same pH, buffer, and temperature, the K_m (apparent) for NADH was 26.0 ± 0.63 μmol/liter with LDH-1 and 23.2 ± 4.6 μmol/liter with LDH-5.

16494. Hust, J. G., **Standard reference materials for thermal conductivity and electrical resistivity,** *Proc. 14th Int. Conf. Thermal Conductivity, Storrs, CT, June 2-4, 1975, Paper R-958,* pp. 221-231 (Plenum Publ. Corp., New York, NY, 1976).

Key words: austenitic stainless steel; electrical resistivity; high temperature; low temperature; standard reference materials; thermal conductivity.

A brief historical review is presented of thermal conductivity reference material research. Recent reference material research by the National Bureau of Standards is described. Critically evaluated thermal conductivity and electrical resistivity data are summarized for the following three Standard Reference Materials now available from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C.: electrolytic iron (4 to 1000 K), austenitic stainless steel (4 to 1200 K), and tungsten (4 to 3000 K).

16495. Jesch, R. L., **Repeatability of SMA coaxial connectors,** *CPEM Digest,* pp. 103-104 (1976).

Key words: coaxial connectors; insertion loss; microwave; reflection coefficient magnitude; repeatability.

SMA connectors in three different configurations were investigated for variation of reflection coefficient magnitude and insertion loss for a given SMA connector connect-disconnect sequence. Repeatability measurements were taken over the frequency range of 2 to 18 GHz for reflection coefficient and over the frequency range of 2 to 12.4 GHz for insertion loss on the National Bureau of Standards' Automatic Network Analyzer. A sample of variation of reflection coefficient magnitude is given for one SMA connector configuration. This variation was much smaller than was expected for SMA connectors.

16496. Jespersen, J. L., **A survey of time and frequency dissemination techniques,** *Proc. 24th Annual Frequency Control Symp., Atlantic City, NJ, Apr. 27-29, 1970,* pp. 322-324 (U.S. Army Electronics Command, Ft. Monmouth, NJ, 1970).

Key words: broadcast; communication; frequency; ratio; synchronization; time.

There are a number of common elements which characterize most time dissemination systems. Among the more important are: accuracy, repeatability, coverage, possibilities for improvement, cost to establish and maintain, ambiguity, time required to obtain answer, ease of use, and cost to the user. At the present time, there does not appear to be any single system which incorporates all of the desired characteristics. The relative importance of these characteristics varies from one user to the next and the kind of tradeoff that one user is willing to make is not a suitable tradeoff for another. Some of the systems such as WWV, were built specifically for the purpose of time and frequency dissemination while others such as TV have considerable potential. These systems and others will be discussed and compared with reference to the characterizing elements enumerated earlier, and some unresolved problems for the future will be considered.

16497. Johnson, W. L., McNeil, J. R., Collins, G. J., Persson, K. B., **CW laser action in the blue-green spectral region from Ag II,** *Appl. Phys. Lett.* **29,** No. 2, 101-102 (July 15, 1976).

Key words: charge transfer; lasers; sputtering; visible.

We have observed 18 cw laser transitions in Ne-Ag mixtures spanning the wavelength region from 408.6 to 585.2 nm. The upper laser levels of Ag II are judged to be pumped by a charge-transfer reaction between a ground-state neon ion and a ground-state Ag I atom resulting in simultaneous ionization and excitation of the silver atom. Output characteristics of the Ag II laser transitions as a func-

tion of neon pressure and discharge current are presented. The two strongest transitions are 478.8 and 502.7 nm in the blue and green, respectively.

16498. Kamper, R. A., **RF applications of the Josephson effect,** *Microwave J.* **19,** No. 4, 39-41, 52 (Apr. 1976).

Key words: high frequency; infrared; Josephson effect; measurements; superconductivity.

This paper reviews progress to date in applying the Josephson effect to microwave detectors, mixers, parametric amplifiers, and measuring systems.

16499. Kanda, M., **An error analysis for absolute flux density measurements of Cassiopeia A,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 3, 173-182 (Sept. 1976).

Key words: accuracy; antenna; calibration; Cassiopeia A; error analysis; flux density; G/T (system gain/system noise temperature); ground station; radio star.

An error analysis for absolute flux density measurements of Cas A is discussed. The lower-bound quadrature-accumulation error for state-of-the-art measurements of the absolute flux density of Cas A around 7 GHz is estimated to be 1.71 percent for 3σ limits. The corresponding practicable error for the careful but not state-of-the-art measurements is estimated to be 4.46 percent for 3σ limits.

16500. Kanda, M., Larson, T. R., **Stability of silicon avalanche noise diodes at K and K_a bands,** *CEPM Digest*, pp. 215-217 (1976).

Key words: silicon avalanche diode; solid state noise source; stability.

A statistical analysis is given for the stability of silicon avalanche noise diodes at K and K_a bands. A brief discussion of a statistical measure for stability and the measurement techniques are given. Cross-correlation coefficients of output noise from the noise diodes and their environmental factors are evaluated in order to examine the causes of the observed instabilities of noise diodes.

16501. Komarek, E. L., **An automated broadband system for measurement of one-port microwave parameters,** *CPEM Digest*, pp. 167-170 (1976).

Key words: application of six-port junction concept; automated measurements; broadband measurements; microwave measurements; microwave power measurements; one-port parameters; six-port junction.

A broadband measurement system has been implemented for determining microwave parameters of one-port devices in the 1-18 GHz frequency range using the six-port junction concept and automation techniques. Although not complete, performance evaluation results show that the system compares favorably with other automated and manually operated measurement methods.

16502. Krauss, M., **Analysis of NH spectrum,** (Proc. IAU Colloq. No. 25, Greenbelt, MD, Oct. 28-Nov. 1, 1974), Paper in *NASA SP-393, The Study of Comets*, B. Donn, M. Mumma, W. Jackson, M. A. Hearn, and R. Harrington, Eds., Part 2, pp. 848-852 (Scientific and Technical Information Office, National Aeronautics and Space Administration, Washington, DC, 1976).

Key words: comet; electric-dipole transition; excited states; NH; spin-orbit coupling; transition probability.

The NH cometary spectra is examined within the context of the radiation equilibrium model. The total fluorescent rate for the $A^3\Pi$-$X^3\Sigma^-$ transition is found to be less than 10^{-2} S^1 and the rate for the $c^1\pi$ $^1\Delta$ transition is estimated to be comparable. A semiempirical calculation of the spin-orbit induced $a^1\Delta$-$X^1\Sigma^-$ transition finds the rate to be about 5 S^1. Any $^1\Delta$ NH formed in an initial photodissociation would radiate to the ground state before it can be excited. The photochemical origin of the NH radical cannot be deduced from the fluorescence spectra.

16503. Kuriyama, M., Boettinger, W. J., Burdette, H. E., **X-ray topographic observations of magnetic domains in Czochralski-grown nickel single crystals in anomalous transmission geometry,** *J. Appl. Phys.* **47,** No. 11, 5064-5068 (Nov. 1976).

Key words: crystal perfection; Czochralski growth; domain walls; magnetic domains; nickel single crystals; surface reflection topography; transmission topography; x-ray diffraction topography.

Ferromagnetic domain walls are observed in large Czochralski-grown nickel single crystals by x-ray double crystal diffraction topography in the surface reflection geometry as well as in the transmission geometry. The images of magnetic domain walls in surface reflection topographs possess almost as good contrast as those in the transmission topographs, and even reveal fine detailed structures distinctly. Based on preliminary arguments, the images observed in the surface reflection topographs are attributed to 180° walls intersecting with the crystal surface obliquely, while the transmission topographs easily image 71° and 109° walls in the interior of the crystals.

16504. Larsen, N. T., **A new self-balancing DC-substitution RF power meter,** *CPEM Digest*, pp. 203-205 (1976).

Key words: bolometer; microwave; power measurement.

Problems intrinsic in self-balancing Wheatstone bridges have led to the development of a new dc substitution microwave power meter. The new instrument allows four-terminal measurement of bolometer resistance and affords improved accuracy and lower noise at a lower cost than earlier instruments. Measurement errors due to imperfect behavior of the servo system are typically less than 0.01 percent.

16505. Ledbetter, H. M., Weston, W. F., **Low-temperature elastic properties of some copper-nickel alloys,** *Proc. IEEE Symp. on Ultrasonics, Los Angeles, CA, Sept. 22-24, 1975*, pp. 623-627 (IEEE, New York, NY, 1976).

Key words: bulk modulus; compressibility; copper; copper alloys; elastic constants; Poisson ratio; pulse-echo method; resonance method; shear modulus; sound velocity; Young's modulus.

The polycrystalline elastic properties of Cu, Cu-10 Ni, and Cu-30 Ni were determined between room temperature and liquid-helium temperature using both pulse-echo (10 MHz) and resonance (60 kHz) methods. The temperature dependence of all three materials is regular. The composition dependence of the elastic constants is reviewed and new composition dependences are proposed.

16506. Lias, S. G., Ausloos, P., Horvath, Z., **Charge transfer reactions in alkane and cycloalkane systems. Estimated ionization potentials,** *Int. J. Chem. Kinet.* **VIII,** 725-739 (1976).

Key words: alkane ions; alkanes; charge transfer; ion-cyclotron resonance; ion-molecule reactions; ionization potentials; rate constants.

Rate constants of charge transfer reactions k_{CT}, involving C_3-C_9 alkanes and cycloalkanes, have been determined in an ion cyclotron resonance mass spectrometer. The rate constants are significantly lower than the corresponding rate constants for collision when the reaction is less than about 0.5 eV exothermic for linear alkane ions, or less than about 0.2 eV exothermic for cycloalkane ions. In this region of low reaction efficiency, the efficiency of reaction with linear or branched alkanes seems to depend primarily on reaction exothermicity. (The efficiencies of reaction of a given ion with cyclic alkanes also depend on ΔH_{rn}, but are higher than for reactions with other compounds.) Although the lowered reaction efficiencies probably

result, at least in part, from unfavorable Franck-Condon factors in the energy range near the ionization onset, quantitative correlations between reaction efficiency and estimated relative Franck-Condon factors were not observed. When the enthalpy of reaction is small (less than about -0.15 eV), it is seen that the reverse charge transfer can also occur, and equilibrium is established under the condition of these experiments. From the observed equilibrium constants, values for the standard free energy change are derived, and assuming that ΔS is small for electron transfer equilibria, values of ΔH_{rn} are estimated. In the case of the equilibria involving cyclohexane ion, these values of ΔH_{rn} lead to estimates of the ionization potentials of methylcyclopentane, 3-methylpentane, *n*-octane, 2,2-dimethylbutane, and 2,3-dimethylbutane, which are lower than the ionization potentials of cyclohexane, that is, < 9.88 eV, although all these compounds had previously been reported to have ionization potentials above 10.03 eV. That the ionization potentials are indeed lower than 10.03 eV is confirmed by determining the quantum yields of ionization with 10.03-eV photons.

It is pointed out that the conclusions reached here apparently also apply to the charge transfer reactions of alkane ions in the liquid phase.

16507. Lightbody, J. W., Jr., Penner, S., Fivozinsky, S. P., Hallowell, P. L., Crannell, H., **Electron scattering from vibrational nuclei,** *Phys. Rev. C* **14,** No. 3, 952-964 (Sept. 1976).

Key words: anharmonicities; branching ratio; charge distribution; electron scattering; quadrupole phonons; vibrational nuclei.

We present electron scattering form factors for the ground states and several low energy quadrupole excitations of the nuclei ^{52}Cr, ^{110}Pd, ^{114}Cd, and ^{116}Sn. For ^{116}Sn we also present the form factor for the lowest octupole excitation. From these data we derive ground state charge distribution parameters as well as $B(EL)$ values. We attempt to interpret the observed 2^+ states as the one- and two-phonon states of an anharmonic vibrational model. Predictions are made for the electromagnetic decay branching ratios and excited state electric quadrupole moments.

16508. Lightbody, J. W., Jr., **Electron scattering from one- and two-phonon vibrational states,** *Physics Lett.* **38B,** No. 7, 475-479 (Apr. 3, 1972).

Key words: admixture; anharmonicities; branching ratios; electron scattering; phonons; reorientation effect.

Admixtures of one- and two-phonon states are required to fit (e, e′) form factors for the lowest two 2^+ states in several even-even vibrational nuclei. These anharmonic wave functions correctly reproduce radiative branching ratios and excited state quadrupole moments.

16509. Little, W., Wakefield, J., Heim, L., Alfred, C., Zapf, T., Manney, C., **An NBS developed automatic network analyzer,** *CPEM Digest*, pp. 130-133 (1976).

Key words: attenuation; automated; bolometer mount efficiency; measurements; network analyzer; phase; reflection coefficient.

This paper describes a precision automated measurement system that has been under development at NBS since 1971 for the frequency range of 0.1 to 12.4 GHz. The system has been designed to measure attenuation, phase shift, reflection coefficient, and bolometer mount efficiency with accuracy as good as or better than can be achieved with present state-of-the-art manual measurement techniques (approximately an order of magnitude better than commercially available ANA's). The paper also presents recent measurement results that have been achieved with the system.

16510. Little, W. E., Yates, B. C., **Reflection coefficient standards for automated network analyzers,** *CPEM Digest*, pp. 128-129 (1976).

Key words: automatic; broad frequency; equations; network analyzers; open circuit reflection coefficient; short circuit; standards.

This paper describes the development and use of broad frequency band reflection coefficient standards for rectangular and coaxial waveguide. Equations for both the magnitude and phase angle of the reflection coefficient of "off-set" short circuits are presented so that these values can be calculated as a function of frequency. An equation for the phase angle of the coaxial "open circuit" reflection coefficient is given in terms of the open circuit capacitance and frequency. Also, an empirical equation is given that allows an estimate of the "open circuit" reflection coefficient magnitude.

16511. McNeil, J. R., Johnson, W. L., Collins, G. G., Persson, K. B., **Ultraviolet laser action in He-Ag and Ne-Ag mixtures,** *Appl. Phys. Lett.* **29,** No. 3, 172-174 (Aug. 1, 1976).

Key words: He-Ag and Ne-Ag mixtures; laser action; ultraviolet laser action.

We report eight new laser transitions which span the wavelength region from 220 to 400 nm. Six of the ultraviolet transitions are observed in Ne-Ag mixtures and two are observed in He-Ag mixtures. The 227.8- and 224.3-nm laser transitions of Ag II, $5d^3D_2$-$5p^3P_1^0$ and $5d^1S_0$-$5p^1P_1^0$ respectively, are the shortest-wavelength cw laser transitions reported in the literature to date. Output characteristics of the ultraviolet laser transitions as a function of buffer gas pressure and discharge current are presented. The strongest laser transition $4d^85s^2\ ^1G_4 \rightarrow 4d^85p^3F_3^0$, at 318.1 nm, provides single-line peak output power of 350 mW. The output power does not appear to saturate at the limit of our input current, 50 A.

16512. Meijer, P. H. E., Lockhart, R. G., Niemeijer, T., **Influence of crystallographic displacement and *g*-factors on the ground state of cerous magnesium nitrate,** *Solid State Commun.* **18,** No. 4, 473-474 (1976).

Key words: cerous magnesium nitrate; crystal structure; *g*-factors; ground state energy; Luttinger-Tisza method; translation vectors.

Since the thermodynamic properties of cerous magnesium nitrate play such an important role in low temperature physics we computed the influence of all variations still possible under the given set of known data: Small variation in the lattice structure, in particular the displacement of the center plane, small variations of the *g*-factor and the combination thereof.

16513. Mies, F. H., **Polarization of OH radiation,** (Proc. IAU Colloq. No. 25, Greenbelt, MD, Oct. 28-Nov. 1, 1974), Paper in *NASA SP-393, The Study of Comets*, B. Donn, M. Mumma, W. Jackson, M. A. Hearn, and R. Harrington, Eds., Part 2, pp. 843-847 (Scientific and Technical Information Office, National Aeronautics and Space Administration, Washington, DC, 1976).

Key words: comets; fluorescence; OH-18-cm radiation; optical pumping; polarization.

In the absence of collisions, optical pumping of cometary OH by solar ultraviolet radiation determines the relative population of OH molecules in the Λ-doubled levels of the $^2\Pi_{3/2}$ ground state, and also produces an alignment of the magnetic sublevels along the axis of the incident solar radiation. This results in a linear polarization of both the u.v. fluorescent spectrum and the 18-cm OH radiowave spectrum.

16514. Murphey, W. M., Sherr, T. S., Bennett, C. A., **Societal risk approach to safeguards design and evaluation,** (Proc. 16th Annual Meeting Institute of Nuclear Materials Management, Inc., New Orleans, LA, June 18-20, 1975), Paper in *Nuclear Materials Management* **IV,** No. III, 588-606 (1975).

Key words: nuclear materials safeguards; safeguards evaluation; safeguards system design; societal risk.

A comprehensive rationale for safeguards design and evaluation, and a framework for continuing systematic assessment of the system's effectiveness and efficient allocation of available safeguards resources so as to provide a balanced protection has been developed. The general objective of safeguards has been stated as: "to achieve a level of protection against ... [willful actions involving the possession of nuclear materials or the sabotage of nuclear facilities] that insures against a significant increase in the overall risk of death, injury, or property damage to the public from other causes beyond the control of the individual." Consistent with this objective, the societal risk approach was chosen as the basis for designing and evaluating the safeguards system. The approach considers the frequency (or likelihood) of occurrence of an antisocial act involving nuclear materials or facilities and the magnitude of the effects on society should such an act be successfully perpetrated. The analysis starts with the identification of the set of illegitimate final acts, or "events," which involve nuclear materials or nuclear facilities. These events are used as a basis for identifying the adversary action sequences that could produce the final events, and as a basis for considering the consequences to the public. The paper presents a summary of the societal risk approach, considerations relating to frequency of attempt, an adversary action tree approach to analysis of adversary activities, the structure of the safeguards system implied by the adversary actions, and implications relating to safeguards system design and evaluation arising from the societal risk approach.

16515. Okabe, H., **Photochemistry,** Paper in *Encyclopedia of Chemistry Uses (Utet Sansoni Edizioni Scientifiche)*, **V,** 610-615 (Firenze, Italy, 1976).

Key words: bond energy; chain reaction; determination of photochemical mechanism; flash photolysis; intermittent illumination; photochemical principles; photochemical reaction of atoms and molecules; photochemistry in the atmosphere; photochemistry of air pollution; primary and secondary photochemical processes.

The principles and processes of photochemistry are described at an elementary level. The importance of quantum yield measurement is emphasized. Main topics covered in this article are chain reaction, flash photolysis, effect of intermittent illumination, examples of photochemical reaction in atoms and molecules, application of photochemistry for the measurement of bond energy, photochemistry in the atmosphere and photochemistry of air pollution.

16516. Reeve, G. R., Arthur, M. G., **A standard percent modulation measurement system,** *CPEM Digest*, pp. 165-166 (1976).

Key words: amplitude modulation; instrument landing system; modulation measurements; modulation meter; percent modulation.

This paper describes a precision percent modulation measurement system constructed by the Electromagnetics Division, National Bureau of Standards, for calibration of secondary standards for instrument landing system (ILS) generators and meters. A description of the electronics is presented along with the estimated measurement uncertainty.

16517. Reite, M., Zimmerman, J. E., Edrich, J., Zimmerman, J., **The human magnetoencephalogram: Some EEG and related correlations,** *Electroencephalogr. Clin. Neurophysiol.* **40,** 59-66 (1976).

Key words: magnetic evoked response; magnetoencephalography.

Simultaneous magnetoencephalographic (MEG) and electroencephalographic (EEG) data were recorded from four normal adults. Spectral analysis suggested that the MEG and EEG data were produced by similar but nonidentical generator systems; the MEG recorded here may be generated by intrasulcal cortex. A magnetic averaged evoked response to flash was recorded in one subject, consisting of a waveform similar to and phase-coherent with the simultaneous EEG averaged evoked response, such that cortical negativity was correlated with a magnetic field directed into the scalp.

16518. Riad, S. M., Nahman, N. S., **Application of the homomorphic deconvolution for the separation of TDR signals occurring in overlapping time windows,** *CPEM Digest*, pp. 27-29 (1976).

Key words: homomorphic deconvolution; time domain measurements; time domain reflectometry.

The homomorphic transformation is used to separate a time domain reflectometry (TDR) signal into its rapidly and slowly varying components, respectively. The separation (deconvolution) technique is successful in the case where the multiple reflections cannot be viewed in nonoverlapping time windows as is required by the conventional TDR method.

16519. Ries, F. X., **An international intercomparison of voltage standards at 1 GHz in coaxial transmission line,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 3, 254-255 (Sept. 1976).

Key words: electrical measurements; radio frequency; voltage measurements.

The results of an International Intercomparison of RF voltage at 1 GHz is described. This comparison was sponsored by the High Frequency Working Group of the Comité Consultatif d'Eléctricité (CCE) at the Bureau International des Poids et Mesures (BIPM). Differences between values reported by the five participating laboratories fell within the total uncertainties given by these laboratories. The estimated limits of uncertainty given by the laboratories varied from a few tenths to several percent.

16520. Risley, A. S., Shoaf, J. H., Ashley, J. R., **Frequency stabilization of *x*-band sources for use in frequency synthesis into the infrared,** *IEEE Trans. Instrum. Meas.* **IM-23,** No. 3, 187-195 (Sept. 1974).

Key words: cavity stabilization; frequency multiplication; frequency stability; frequency synthesis; Gunn oscillator; infrared; injection stabilization; klystron; *X* band.

An *X*-band source of excellent frequency stability is needed in infrared frequency multiplication of high order. Such a source has been used in frequency multiplication by a factor of 401 using a point-contact Josephson junction as a frequency multiplier and mixer. Noise data on three *X*-band systems are reported. Two of these systems use klystrons as the source of *X*-band power; the other uses a Gunn oscillator. Each of these three systems employs both cavity and injection stabilization. Injection stabilization, using a quartz-oscillator-driven multiplier chain, provides the second-to-second and minute-to-minute stability needed for the Josephson junction experiment. To our knowledge, this is the first published noise data where cavity and injection stabilization are simultaneously employed. The quality of the best system reported here is much better—both around 1 Hz from the carrier and around 50 kHz from the carrier—than the source used to multiply by a factor of 401 to 3.8 THz.

16521. Rockar, E. M., Forman, R. A., **Polarized luminescence from MgO:Cr^{3+},** *Phys. Rev. B* **14,** No. 8, 3621-3629 (Oct. 15, 1976).

Key words: chromium 3+; crystal vacancies; cubic crystals; depolarization; impurity compensation; luminescence; magnesium oxide; MgO; optical properties; polarized luminescence; symmetry; transition metal ions.

MgO:Cr^{3+} has been used as a model system to study the general case of polarized luminescence from transition-metal impurities in cubic materials. Using polarized exciting light, information can be ob-

tained about the site symmetries of the impurities as well as the dipole character of the absorbing and emitting levels. The data presented are in substantial agreement with previous studies on the line emission spectra of $MgO:Cr^{3+}$ obtained by other techniques. Careful experimental procedures to avoid artifacts are detailed. Experimental values for the polarizations are always significantly smaller than those predicted by theory. A dependence of polarization with chromium concentration was also noted. Probable causes for these effects are discussed.

16522. Roder, H. M., **The heats of transition of solid ethane,** *J. Chem. Phys.* **65,** No. 4, 1371-1373 (Aug. 15, 1976).

Key words: ethane; heat capacity; heat of fusion; heat of transition; transition temperature; triple point.

The existence of a solid-solid transition in ethane is now generally accepted. A value for the heat of transition, 2437 ± 35 J/mol at 89.774 K, together with a new value for the heat of fusion, 279 ± 6 J/mol at 90.337 K, is reported in this work. The sum of the new values is in excellent agreement with the earlier measurements, provided that the heat required to raise the temperature of the solid between transitions is included. The transition temperatures are in agreement with the most recent determinations of other authors.

16523. Ruff, A. W., **Deformation studies at sliding wear tracks in iron,** *Wear* **40,** 59-74 (1976).

Key words: electron channeling; iron; metals; plastic deformation; surfaces; wear.

Determinations have been made of strains on the surface and subsurface of specimens of high purity iron after different distances of sliding wear. The method involved the measurement of loss of intensity (contrast) of particular electron channeling lines obtained from small selected areas near the wear track. A calibration specimen, deformed plastically to a range of strain values, was used to relate the channeling line contrast loss to plastic strain. Strain maps lateral to the wear track and below the original surface were obtained after removing controlled thicknesses of iron by electropolishing. In all cases the maximum strain was found at the track center location at the surface and the strains decreased steadily with depth below the track. With a 50 g load the strains vanished at about 40 μm depth. Significant strains were found to exist outside the wear track boundaries. There was no indication of a soft or less-hardened surface layer in any of the specimens studied.

16524. Sanders, D. M., Blackburn, D. H., Haller, W. K., **A high-temperature transpiration apparatus for study of viscous, incongruently vaporizing glass melts,** *J. Am. Ceramic Soc.* **59,** No. 7-8, 366-368 (Aug. 1976).

Key words: glass; incongruent vaporization; transpiration; vapor density.

The vapor density of sodium over a well-stirred soda-lime-silica glass melt was measured using a newly developed transpiration apparatus. This apparatus uses intense stirring action to produce fresh surfaces throughout the measurement. This feature is necessary to prevent the formation of depleted layers formed by preferential vaporization of one of the glass components. The apparatus design and operating characteristics are discussed.

16525. Schleter, J. C., **A decision structure for a State safeguards system,** (Proc. Symp. Safeguarding Nuclear Materials, Vienna, Austria, Oct. 20-24, 1975). Paper in *Safeguarding Nuclear Materials,* **I,** 199-213 (International Atomic Energy Agency, Vienna, Austria, 1976).

Key words: decision structure; information system; nuclear material diversion; nuclear materials; safeguards; safeguards information system.

An effective structure to direct safeguards decisions within a State's safeguards system is vital in order to minimize the possibility of illicit diversion of nuclear material. In a State each plant usually has some form of information system in operation but it is generally plant specific and often is directed only to management functions. The systematic study, discussed in this paper, is aimed at developing a more comprehensive Safeguards Information System (SIS). The concepts used are applicable to any State's safeguards system. Decision makers are identified and classified. General safeguards and operational tasks are defined for each and, based on these, information sources are identified. The flow structure for information is specified to enable safeguards decision makers to function properly. Concepts used to characterize the SIS and the associated decision structure are discussed.

16526. Schleter, J. C., **A decision structure for plant safeguards,** (Proc. 16th Annual Meeting Institute of Nuclear Materials Management, Inc., New Orleans, LA, June 18-20, 1975). Paper in *Nuclear Materials Management* **IV,** No. III, 406-430 (1975).

Key words: decision makers; decision structure; information flows; nuclear material information systems; nuclear materials safeguards; safeguards.

A systematic study has been performed to determine the information necessary for meaningful safeguards decisions. The resulting Safeguards Information System (SIS) encompasses all decision makers, in general terms, from those at ERDA Headquarters to the operator on the process line. Only decision makers within the plant are considered in this paper. The basic premises and steps employed in developing SIS are described. These include rapid two-level reporting of abnormal situations, identification of the safeguards decision makers, deduction of safeguards information generated and abnormal situations observed by each as a result of operational tasks, and to whom the information is transmitted. The content of information flowing to and from each decision maker from all sources is established and assurance is given that each decision maker receives the necessary information and that extraneous information is held to a minimum. By means of the analysis, a decision structure for safeguards becomes apparent, the decision capability of each decision maker can be specified, and the sources and flows of information necessary for meaningful safeguards decisions can be identified. The application of the general SIS, to serve as the basis of a plant-specific SIS, is also considered.

16527. Siegwarth, J. D., Lawless, W. N., Morrow, A. J., **Dielectric and thermal properties of $Pb_2Nb_2O_7$ at low temperature,** *J. Appl. Phys.* **47,** No. 9, 3789-3791 (Sept. 1976).

Key words: antiferroelectric; dielectric constant; heat capacity; lead pyroniobate; low temperature; polarization.

Measurements of the dielectric constant, polarization, zero-field specific heat, and field-dependent specific heat of polycrystalline $Pb_2Nb_2O_7$ at low temperatures are reported. No evidence for a phase transition at 15 K was found, contrary to previous suggestions of an antiferroelectric transition at 15 K based on dielectric data. The peak in the dielectric constant appears to be due to relaxation phenomena.

16528. Smith, E. W., Giraud, M., Cooper, J., **A semiclassical theory for spectral line broadening in molecules,** *J. Chem. Phys.* **65,** No. 4, 1256-1267 (Aug. 15, 1976).

Key words: *ab initio* potentials; atom-molecule interactions; curved classical trajectories; HCl, CO, CO_2 with He, Ar; rotation-vibration spectra; semiclassical *S*-matrix; spectral line broadening.

A semiclassical *S*-matrix theory is developed and applied to spectral line broadening in linear molecules perturbed by atoms. This theory uses curved classical trajectories determined by the isotropic

part of the atom-molecule interaction and the *S*-matrix is treated to all orders in the interaction. Numerical calculations can be made rather easily even for high quantum numbers. The theory is least accurate for very low quantum numbers, but even then calculations agree to within 10 percent with close coupling results where comparisons could be made. Comparisons were also made with other theoretical approaches using model potentials and with experiments using *ab initio* potential surfaces.

16529. Sorensen, C. M., Fickett, F. R., Mockler, R. C., O'Sullivan, W. J., Scott, J. F., **On lysozyme as a possible high-temperature superconductor,** *J. Phys. C: Solid State Phys. Letter to Ed.* **9,** L251-L254 (1976).

Key words: diamagnetism; light scattering; molecular diffusion; organic molecule; superconductor; susceptibility.

Intensity autocorrelation measurements of the diffusion constant of lysozyme molecules in aqueous solutions as a function of applied magnetic field reveal no evidence of the cooperative behavior proposed by Ahmed, Calderwood, Fröhlich and Smith to explain their observation of a large peak in the diamagnetic susceptibility of lysozyme at an applied field of 600 Oe. Careful susceptibility measurements using a SQUID system show that the diamagnetic susceptibility of lysozyme and lysozyme solutions is constant up to our maximum field of 720 Oe.

16530. Sugar, J. R., **A VOR audiofrequency standard signal source based on digital waveform synthesis,** *CPEM Digest*, pp. 72-73 (1976).

Key words: aircraft navigation systems; digital frequency synthesis; national standards; precision audiofrequency signal generation; precision FM signal generation; precision phase angle generation; radio navigation; VOR.

This unit generates three highly accurate audio signals for use in calibrating the working standards for the calibration of VHF omnirange (VOR) aircraft navigation systems. The three signals are two 30 Hz sine waves and a 9960 Hz carrier, frequency modulated by a 30 Hz sine wave. The phase of one of the 30 Hz signals is adjustable in .01° steps relative to the other two signals. The zero-crossing points of all three signals are accurate to approximately .01° relative to 30 Hz. In order to achieve this level of accuracy the signals are generated digitally and then converted to analog form. A substantial reduction in the required size of read-only-memory for storing the required digital functions is achieved by storing the differences rather than the functions themselves. Error-checking circuits and built-in-test circuits are incorporated to provide an immediate indication of malfunction of the digital circuits.

16531. Tobler, R. L., **Fatigue crack growth and J-integral fracture parameters of Ti-6A1-4V at ambient and cryogenic temperatures,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 601*, 346-370 (1976).

Key words: fatigue crack propagation; fracture toughness; J-integral; low temperature tests; titanium alloys.

Fatigue crack propagation and fracture parameters for 2.03-cm-thick compact specimens of an extra-low-interstitial Ti-6A1-4V alloy were measured at temperatures between 296 K (70 °F) and 4 K (− 453 °F). Plane-strain linear-elastic and J-integral fracture toughness test results were in good agreement: the K_{Ic} values for this alloy decreased from 105 MN/m$^{3/2}$ at room temperature to 54 MN/m$^{3/2}$ at 4 K, and a ductile-to-brittle fracture transition occurred in the range 125 to 76 K (− 235 to − 323 °F). Despite this transition, the fatigue crack growth rates *(da/dN)* of this alloy remained temperature insensitive over the entire ambient-to-cryogenic range. These fatigue and fracture results are compared with data previously reported for a normal-interstitial Ti-6A1-4V alloy.

16532. Truhlar, D. G., Brandt, M. A., **Close-coupling calculations of differential cross sections for elastic scattering and rotational excitation of hydrogen molecules by electrons at 10 and 40 eV,** *J. Chem. Phys.* **65,** No. 8, 3092-3101 (Oct. 15, 1976).

Key words: close-coupling calculations; cross sections; differential cross sections; elastic scattering; electron scattering; exchange (of electrons); hydrogen molecules; inelastic scattering; momentum transfer; polarization (of charge clouds); rotational excitation; scattering theory.

We have performed close-coupling calculations including two rotational states for electron scattering by hydrogen molecules at 10 and 40 eV impact energies. The effective interaction potential was taken as a sum of the static, exchange, and polarization interactions. With no empirical parameters, good agreement with experiments was obtained for the angle dependences and magnitudes of the differential cross sections for both pure elastic scattering and rotational excitation except that there are discrepancies in the elastic scattering at small scattering angles where the experiments are least reliable. Variations of the forms of the exchange and polarization potentials were examined and the effect on the cross sections was small.

16533. Truhlar, D. G., Brandt, M. A., Chutjian, A., Srivastava, S. K., Trajmar, S., **Electron scattering by N_2 at 5 and 10 eV: Rotational-vibrational close-coupling calculations and crossed beam studies of vibrational excitation,** *J. Chem. Phys.* **65,** No. 8, 2962-2969 (Oct. 15, 1976).

Key words: close-coupling calculations; crossed beams; cross sections; differential cross sections; electron scattering; inelastic scattering; nitrogen molecules; polarization potential; scattering; static potential; vibrational excitation.

The ratios of differential cross sections for excitation of the first excited vibrational state to differential cross sections for elastic scattering of N_2 have been measured at scattering angles ranging from 20° to 135° at 5 and 10 eV impact energies. Using previously measured and normalized elastic differential cross sections for N_2, the ratios have been converted to inelastic cross sections. Laboratory-frame close-coupling calculations using a four-state vibrational-rotational basis set and an effective interaction potential developed previously are reported at both energies. It is shown that the four-state treatment of this potential scattering model can account for the approximate magnitude and the qualitative behavior of the cross sections, but there are some significant quantitative differences between theory and experiment.

16534. Wacker, P. F., Bowman, R. R., **Quantifying hazardous electromagnetic fields: Scientific basis and practical considerations,** *IEEE Trans. Microwave Theory Tech.* **MTT-19,** No 2, 178-187 (Feb. 1971).

Key words: nonionizing fields; probes; radiation.

As commonly recognized, the problem of quantifying hazardous electromagnetic (EM) fields is difficult and has not yet been satisfactorily solved. Essentially, this is because people are often exposed to emanations from powerful sources of EM fields at points close to the sources and at points where arbitrary polarization and multipath interference exist. However, the accepted concepts, standards, and most measuring instrumentation are based on simple plane-wave field propagation and so are inadequate for complicated fields.

The complications and problems of quantifying hazardous EM fields involving source-subject coupling, reactive near-field components, multipath components, and arbitrary polarization are examined in some detail. General discussion of dosimetric measurements and hazard survey measurements is given, and also some basic considerations for the design of field probes for these measurements. Recommendations are given for suitable parameters for quantifying complicated EM fields, and essential and desirable characteristics

for hazard survey meters are stated. Several recently designed hazard survey probes are capable of measuring these recommended parameters in many complicated fields of interest, and improved instruments are anticipated.

16535. Yokel, F. Y., **A performance standard for foundations and excavations,** *Civil Eng.* **47,** No. 10, 80-81 (Oct. 1976).

Key words: buildings (codes); excavation; foundations; geotechnical engineering; standards.

Work is now in progress on the preparation of a national standard for foundations and excavations under the ASCE-COS "Committee for Foundation and Excavation Standards," (CFES).

16536. Goodwin, K. E., Maltese, M. D. K., Schleter, J. C., **Diversion path analysis handbook. Volume II. Example,** 225 pages (Division of Safeguards and Security, U.S. Energy Research and Development Administration, Washington, DC, Oct. 1976).

Key words: analysis; diversion of nuclear materials; diversion path analysis; internal control system characterization; nuclear material safeguards; safeguards.

A hypothetical example illustrating the methodology given in Volume I of "The Diversion Path Analysis Handbook" is presented. The process, derived for the example, might be typical of the end of a fabricating process line where plutonium metal bars, originating in an earlier unspecified process step, are cut up and recast into buttons for long term storage. The process is intended to reflect typical actual practice, but in some cases, the parameters have been specially tailored so that as many features of DPA could be illustrated. The example is presented in the format recommended for use when documenting a DPA. It contains all of the basic components necessary for complete documentation and its use assures a common basis for intercomparisons of DPA's, both intra- and inter-plant. Volume II is divided into two parts—the workpaper documentation and the summary report. The former sets forth the bounds of the analysis, the information gathered, the characterization of the process, the specific diversion paths related to the process, and, finally, the results and findings, of the DPA. The summary report, made up of portions of sections already prepared for the workpapers is a concise statement of results and recommendations for management use.

16537. Evans, B. J., Swatzendruber, L. J., **Magnetic hyperfine field structure of iron Urushibara type catalysts,** (Proc. Annual 20th AIP Conf. on Magnetism and Magnetic Materials, San Francisco, CA, Dec. 3-6, 1974), Paper in *Magnetism and Magnetic Materials—1974*, C. D. Graham, Jr., G. H. Lander, and J. J. Rhyne, Eds., No. 24, 291-393 (American Institute of Physics, New York, NY, 1975).

Key words: alloys; aluminum; catalysis; hydrogenation; iron; Mössbauer spectra; zinc.

We have utilized the Mössbauer effect to study the hyperfine field structure of iron Urushibara catalysts. The Mössbauer spectra of those catalysts prepared using zinc show that they consist of a mixture of magnetic and nonmagnetic Fe-Zn alloys. Both the magnetic field distribution in the magnetic phase and the relative amounts of magnetic and nonmagnetic phases depend on the Fe-Zn ratio used in the preparation of the catalyst. This dependence on Fe-Zn ratio is in contrast to iron Urushibara catalysts prepared using aluminum (and Raney iron type catalysts) in which the active phase is almost pure α-Fe, irrespective of the Fe-Al ratio. The activity of zinc prepared iron Urushibara catalysts for certain hydrogenation reactions is known to be greater than that of aluminum prepared iron Urushibara catalysts and the above results suggest a relationship between activity and the modification of the iron catalyst by alloyed zinc. The alloying behavior of the Fe-Zn particles may be analogous to that of the so-called bimetallic clusters observed in other alloy systems.

16538. Deslattes, R. D., Lamotte, M., Dewey, H. J., Keller, R. A., Freund, S. M., Ritter, J. J., Braun, W., Kurylo, M. J., **Isotopic enrichment in laser photochemistry,** (Proc. Second Int. Conf. Laser Spectroscopy, Megève, France, June 23-27, 1975), Lecture Notes in *Physics* **43,** pp. 296-303 (Springer-Verlag, New York, NY, 1975).

Key words: isotope separation; kinetics; lasers; photochemistry.

Laser technology has permitted more efficient study of the chemistry of molecules in excited states. The extent to which isotopic specificity is preserved in going from initial excitation to final product is a valuable diagnostic for excited state chemistry. This report summarizes initial results from several areas of investigation, each of which suggests that laser stimulation may offer more than simple rate enhancement.

16539. McCulloh, K. E., **Energetics and mechanisms of fragment ion formation in the photoionization of normal and deuterated water and ammonia,** *Int. J. Mass Spectrom. Ion Physics* **21,** 333-342 (1976).

Key words: ammonia; appearance potential; autoionization; deuterated species; enthalpy of formation; ionization potential; NH_2^+; OH^+; photoionization; predissociation; Rydberg states.

Fragment photoion yield curves have been obtained for OH^+ from H_2O at 215 and 298 K and for NH_2^+ from NH_3 at 160 and 298 K. The results indicate that for both molecules the initial rotational energy is completely available for fragmentation. Appearance potentials, corrected to 0 K, are 18.115 ± 0.008 eV for OH^+ from H_2O and 15.768 ± 0.004 eV for NH_2^+ from NH_3. Assuming zero excess energy at threshold, the values 309.0 ± 0.2 and 302.7 ± 0.1 kcal mol^{-1} are obtained for the standard enthalpies of formation of OH^+ and NH_2^+, respectively, leading to the derived ionization potentials $I(OH) = 12.995 \pm 0.009$ eV and $I(NH_2) = 11.17 \pm 0.05$ eV. The observed yield of OH^+ from H_2O deviates markedly from values calculated on the assumption that fragmentation occurs exclusively by predissociation from excited vibrational levels of H_2O^+ ($\tilde{B}\,^2B_2$), suggesting that Rydberg series converging to these levels play an important role in OH^+ production. Appearance potentials for OD^+, NHD^+ and ND_2^+ are reported.

16540. Paule, R. C., **Mass spectrometric studies of Al_2O_3 vaporization processes,** *High Temp. Sci.* **8,** 257-266 (1976).

Key words: AlO_2; Al_2O_3; emissivity; evaporation coefficient; Langmuir vaporization; optical pyrometry; radiation heating; vapor pressures.

An investigation of the radiative and evaporative properties of Al_2O_3 samples has been made. These observed properties interact in a manner such that, upon melting, the rate of evaporation is observed to increase discontinuously. This phenomenon had previously been attributed to a change in the evaporation coefficient. The current investigation has shown that the evaporation coefficient for Al_2O_3 is constant and that the observed increase in vaporization is due to an increase in the temperature which, in turn, is due to a discontinuous increase in the emissivity. Relative vapor pressure measurements were also made in this study, and the reported existence of the vapor species AlO_2 was not confirmed. All other reported vapor species were confirmed.

16541. Ederer, D. L., **Erratum: Cross section profiles of resonances in the photoionization continuum of krypton and xenon (600-400 Å),** *Phys. Rev. A ERRATA* **14,** No. 5, 1936-1937 (1976).

Key words: cross section; inner-shell excitation; krypton; photoionization; vacuum ultraviolet; xenon.

Equation (4) in this paper is incorrect. It should read:

$$\sigma(E) = C(E) + (2\sigma_a q(\Gamma/2)(E - E_r) + \sigma_d(q^2 - 1)(\Gamma/2)^2)/(E - E_r)^2 + (\Gamma/2)^2$$

Unfortunately the incorrect form of the cross section was inadvertently used to transform the parameters from the Fano representation to the Shore representation, consequently, some of the parameter values listed in Tables I and II are incorrect. The corrected tables are shown. The change in some of the a_i's will slightly effect the cross-section profiles of the resonance shown in figs. 1 and 2.

16542. Hocken, R., Horowitz, M. A., Greer, S. C., **Critical anomaly in the dielectric constant of a nonpolar pure fluid,** *Phys. Rev. Lett.* **37,** No. 15, 964-967 (Oct. 11, 1976).

Key words: Clausius-Mossotti equation; critical phenomena; dielectric constant; sulfur hexafluoride.

We report measurements of changes in the dielectric constant ϵ of SF_6 along a near critical isochore. We find an anomalous increase in ϵ. The amplitude of the anomaly is about 10 times larger than the one predicted by current theories, which assume a constant polarizability.

16543. Plummer, E. W., **Interaction of single atoms with atomically defined surfaces,** (Proc. Conf. Applications of Field-Ion Microscopy to Physical Metallurgy and Corrosion, Georgia Institute of Technology, Atlanta, GA, May 15-17, 1968), Paper in *Physical Metallurgy and Corrosion*, R. F. Hochman, E. W. Müller and B. Ralph, Eds., pp. 371-389 (1968).

Key words: adatom; binding energy; field ion microscope; surface.

The role of the field ion microscope in surface studies is illustrated by reviewing briefly several unique experiments which have been conducted. These include experiments on work function, condensation, surface rearrangement and self diffusion, and atomic binding at the surface. The details of the experiment on atomic bonding of individual atoms on single crystal planes is considered in more detail to illustrate the capabilities of this technique for investigating the fundamental properties of the surface-adatom interaction on an atomically defined surface.

16544. Simiu, E., **Wind climate and failure risks,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** No. ST9, 1703-1707 (Sept. 1976).

Key words: buildings (codes); failure; probability distribution functions; reliability; structural engineering; wind (meteorology); wind pressure.

The relation is examined between risk of failure, degree of wind sensitivity, type of wind climate, and mean recurrence interval used in design. The results presented are based on the assumption, used in the ANSI A58.1 Standard, that the probabilistic behavior of extreme wind speeds is adequately modeled by distribution functions of the largest values, the parameters of which are estimated from the data consisting of the largest yearly wind speed for every year of record. These results show that a strong correlation exists between probability of failure and type of wind climate, as defined quantitatively by the parameters of the extreme wind distribution. All other relevant factors being equal, including the degree of sensitivity to wind, it was found that the probability of failure of a member may increase considerably as a function of type of wind climate. It is suggested that the effect of the type of climate, as defined in the paper, be taken into account in design.

16545. Simiu, E., Filliben, J. J., **Probability distributions of extreme wind speeds,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** No. ST9, 1861-1877 (Sept. 1976).

Key words: buildings (codes); hurricanes; probability distribution functions; reliability; risk; statistical analysis; storms; structural engineering; wind pressure; wind speed.

An automated technique is presented for determining an appropriate distributional model for the largest yearly wind speeds. With a view to assessing the validity of current probabilistic approaches to the definition of design wind speeds, this technique was used in a study of extreme wind speeds based on records taken at 20 U.S. weather stations. The following results were obtained: (1) At 83 percent of the stations not susceptible to experiencing hurricane-force winds, the series of the largest annual wind speeds were well fit by Type I probability distributions of the largest values; (2) the assumption that Type II distributions with $\gamma = 9$ are generally representative of such stations was not confirmed; (3) type I probability distributions do not appear to describe correctly the behavior of extreme winds in regions subjected to special winds, e.g., hurricanes; and (4) in such regions, 20-yr data samples may provide a misleading picture of extreme wind behavior.

16546. Page, C. H., **Torque on a bar magnet,** *Am. J. Phys.* **44,** No. 11, 1104-1105 (Nov. 1976).

Key words: magnet; magnetization; torque.

If all magnetic quantities are defined via fields, with no use of poles and with magnetic moment defined as the volume integral of magnetization, energy considerations yield the torque on a magnet immersed in a permeable fluid in an external field. Although the torque on a disk magnet is proportional to $\mathbf{B}$, the torque on a needle magnet is proportional to $\mu_0\mathbf{H}$, as reported experimentally by Whitworth and Stopes-Roe. The experiment does not prove either A. E. Kennelly [J. Eng. Educ. **27,** 290 (1935)] or Sommerfeld to be right or wrong, but demonstrates that magnetic theory based on *poles* cannot be applied to *magnets*, and thereby strengthens the philosophy that electromagnetic theory should be based on fields.

16547. Snell, J. E., Kusuda, T., Didion, D. A., **Energy conservation in office buildings: Some United States examples,** *Proc. International CIB Symp. on Energy Conservation in the Built Environment, Watford, England, Apr. 6-8, 1976,* pp. 1-34 (International Council for Building Research, Studies and Documentation, Rotterdam, The Netherlands, 1976).

Key words: commercial buildings; energy conservation; energy consumption; Manchester office building; National Bureau of Standards; New York State offices; office buildings.

The purpose of this paper is to describe recent experience in the United States and, in particular, the National Bureau of Standards (NBS) with energy conservation in office buildings. The NBS, working in cooperation with the Energy Research and Development Administration (ERDA) and the General Services Administration (GSA), is evaluating the energy efficiency of a demonstration office building in Manchester, New Hampshire. NBS utilized its thermal performance computer program (NBSLD) to evaluate a variety of energy conservation design alternatives for this building. These results are described and the current status of the project is reported. The NBS has conducted studies of energy conservation potentials in its own buildings at the Gaithersburg, Maryland, site. These measures include operational as well as retrofit actions. The results of actual tests and computer evaluations of predicted performance are discussed. Overall savings in energy use (fuel oil, fuel gas, and purchased electricity) of 20 percent have been achieved. An additional 20 percent reduction in energy use is expected from planned retrofit, including use of computerized HVAC controls. The NBS also has been working with an ad hoc industry group, representing owners and managers of commercial buildings, toward the development of self-help guidelines these managers can use in achieving energy conservation retrofit cost-effectively in their own buildings. Data collected to date and current status of these activities are reported. Many post-war office buildings were designed and constructed which are inimical to present energy conserving criteria. The excessive use of glass and illumination prevailed, as well as inefficient, although first-cost inexpensive, HVAC systems. Controls for building illumination and space

conditioning were often inadequate for energy conservation operations. Therefore, these areas represent major opportunities for energy conservation in existing, as well as new, office buildings in the U.S., and are the target of a major effort by NBS and the Federal Government in general.

16548. Marron, B., Fife, D., **Online systems—Techniques and services,** Chapter 5 in *Annual Review of Information Science and Technology,* M. E. Williams, Ed., **11,** 163-210 (American Society for Information Science, Washington, DC, 1976).

Key words: bibliographic information systems; computer technology; information storage and retrieval; interactive systems; online services; online systems.

The Annual Review of Information Science and Technology, published by the American Society for Information Science, reviews the contemporary trends, progress, and problems in the major areas of information science. This chapter on "Online Systems—Techniques and Services" is intended for Volume 11 to be published in September 1976, and reviews the literature of 1974 and 1975.

The first section treats computer technology, networks and communications, and software, with particular emphasis on the significance of these techniques for future online systems design. Next there is coverage of online services with detail on promotion and pricing of services, use of multiple services, online services in libraries, retrieval of nonbibliographic information, and document delivery. The third section treats the user interface in online systems, especially the role of the intermediary, design criteria for user-oriented systems, user training, and interface standardization. Finally some issues and problems of online systems are discussed.

16549. Cali, J. P., **The NBS Standard Reference Materials program: An update,** *Anal. Chem.* **48,** No. 11, 802A-818A (Sept. 1976).

Key words: accuracy; measurement; measurement compatibility; National Bureau of Standards; reference materials; standard reference materials; Standard Reference Materials program.

Ten years ago, almost to the day, the National Bureau of Standards reported in *Analytical Chemistry* the status of its Standard Reference Materials program. In view of the NBS 75th anniversary of its founding coinciding, as it does, with our Nation's 200th Anniversary, it seems especially fitting that an update of that report be made. In this short 10-year period, more substantive changes have taken place than occurred over the first 60 years of the program's existence. It is the purpose of this report to recapitulate these events and to attempt to predict what the future holds in store.

16550. Kusuda, T., **Control of ventilation to conserve energy while maintaining acceptable indoor air quality,** (Proc. ASHRAE Symp. on Ventilation Control, Semiannual Meeting, Dallas, TX, Feb. 1-5, 1976), *ASHRAE Trans.* **82,** Part 1, 1169-1182 (American Society of Heating, Refrigerating and Air Conditioning Engineers, New York, NY, 1976).

Key words: air quality; intermittent operation; maximum allowable concentration of CO_2; New York City schools; ventilation.

Basic requirements of ventilation with respect to the undesirable increase of building air contaminants are discussed. A mathematical model for determining the increase of contaminants concentration with time was developed and verified by applying it to the observed CO_2 increases in the New York City School experiment. Equations, tables and graphs were developed for estimating the CO_2 buildup and possible energy saving obtainable by using intermittent operation of ventilation systems. It is concluded that, if properly implemented, intermittent operation of ventilation systems could reduce the energy requirement for heating the ventilating air by as much as 40 percent under typical design conditions.

16551. Cotton, I. W., Grubb, D. S., **Criteria for the evaluation of data communications services,** *Proc. Symp. IEEE Trends and Applications 1976: Computer Networks, Gaithersburg, MD, Nov. 17, 1976,* pp. 71-78 (Institute of Electrical and Electronics Engineers, New York, NY, 1976).

Key words: computer communications; computer networking; data communications; networks; performance requirements; telecommunications.

The quality of telecommunications services that are used as a means of interchanging information between information processing systems or between terminals and systems is determined by a number of parameters. This paper examines the following characteristics of telecommunications services: 1. Transfer Rate; 2. Availability; 3. Reliability; 4. Accuracy; 5. Channel Establishment Time; 6. Network Delay; 7. Line Turnaround Delay; 8. Transparency; 9. Security.

These parameters are all defined and their significance discussed.

16552. Engen, G. F., **Comments on "Practical analysis of reflectometers and power equation concepts",** *IEEE Trans. Instrum. Meas.* **IM-23,** No. 1, 104-105 (Mar. 1974).

Key words: power equation concepts; reflectometers.

Although an apparent objective of the cited paper is to yield additional insight into the power-equation concept, the reader is cautioned that the accompanying analysis is based more on intuitive concepts than mathematical rigor.

Some of the conclusions are, at most, only approximately true. These need to be identified and their associated errors evaluated if the requirements of careful metrology are to be satisfied.

In addition to the consideration of these questions, this correspondence also includes a more careful statement concerning the insensitivity of the power-equation methods to connector problems.

16553. Davis, R. M., **Systems of the 1980s—The U.S. perspective,** (Proc. Conf. Meeting XXXV on A Preview of the 1980s and Distributed Processing, Amsterdam, Holland, Nov. 18-20, 1975), *Document No. EC35, Session C,* pp. 27-43 (Diebold Europe S.A., Frankfurt, Germany, 1976).

Key words: automated reading technology; circuitry; computer applications; computer engineering; distributed systems; interface standards; memory technology; protocols.

Computer systems of the 1980s will be used in applications such as data acquisition and validation, recordkeeping, management information systems, real-time control, real-time monitoring, modeling, simulation, individualized services, scheduling, allocation, dispatching, and scientific and research investigations. These systems will serve primarily two sets of customers. One set is composed of large single organizations using computer systems to manage diversified activities and economic communities using computer systems to link members together. The second set will be individual users needing autonomous dedicated computer systems which can be interconnected to larger computer service networks or other individuals. The 1980s will see computer networks containing computers and computer modules of all sizes, independent memories and large variety of access terminal and automated input devices. However, the present lack of information controls, privacy safeguards, audit procedures, performance measures for real-time control systems, interface standards, software validation and documentation standards will have to be overcome to assure acceptability of the envisioned systems.

16554. Engen, G. F., Hudson, P. A., **International intercomparison of power standards at 3 GHz,** *IEEE Trans. Microwave Theory Tech.* **MTT-19,** No. 4, 411-413 (Apr. 1971).

Key words: bolometer mount; connector compatibility; directional coupler; interlaboratory standards.

An international intercomparison of microwave power at 3 GHz has recently been completed. This comparison was initiated at a meeting of the High Frequency Working Group of the Comite Consultatif d'Electricite (CCE) which met at the Bureau International des Poids et Mesures (BIPM) in May, 1965. At that time, the U.S. National Bureau of Standards (NBS) was designated as the pilot laboratory. The other laboratories, in order of their participation, are the following: for Canada, National Research Council (NRC); for the U.S.S.R., All-Union Research Institute of Metrology imeni D. I. Mendeleyev (VNIIM); for the German Democratic Republic, Deutsches Amt für Messwesen und Warenprüfung (DAMW); and for Japan, the Electrotechnical Laboratory (ETL).

16555. Alperin, H. A., Rhyne, J. J., Pickart, S. J., **Neutron scattering from an amorphous ferrimagnet,** *Proc. Int. Conf. of Magnetism, Moscow, USSR, Aug. 22-28, 1973,* **IV,** 358-366 (International Union of Pure and Applied Physics, The Academy of Sciences of the USSR, Moscow, Russia, 1974).

Key words: amorphous magnetism; direct current sputtering; inelastic neutron scattering; magnetic structures; magnetism; neutron diffraction; rare earth alloys.

Neutron diffraction measurements have been taken on a 2-axis spectrometer as a function of temperature for sputtered $TbFe_2$. Difference patterns between the measurements as a given temperature and the measurement at $T > T_c$ show that the spin and atomic distribution is amorphous. The elastic and inelastic components of the scattering have also been measured separately by using a 3-axis spectrometer. These results show that for $T > T_c$, no coherent magnetic structure remains; the magnetic scattering is all inelastic. An anomalous low-angle tail present in the data is assumed to arise from magnetic inhomogeneities 20-30 Å in size. Application of a magnetic field of ~ 3 kOe at 77 K can cause these inhomogeneities to grow in size as well as to cause a small rearrangement of the spin distribution. Inelastic scattering experiments using time of flight analysis were made to obtain the differential cross section $S(Q,\omega)$ at room temperature and at $T > T_c$. At $T > T_c$ the spectrum is seen to be paramagnetic-like, as expected. At room temperature, comparison with the spectrum for a polycrystalline sample shows the amorphous sample to have a spectrum which is more spread out and shifted to lower energies. This result is in accord with recent calculations.

16556. Mahaffey, C. T., **Metrication problems in the construction codes and standards sector,** *Constr. Specifier,* pp. 25-28, 30-32, 34-37 (June 1976).

Key words: building regulations; dimensional coordination; metric conversion; planning and scheduling.

This report is a response to a request for an outline of the problems to be faced by the building standards development and building regulatory sectors of the American building industry. It includes a discussion of the SI metric units themselves, giving examples of the conventions regarding their use adopted in other countries to illustrate the nature of the decisions that must be made by the U.S. building industry. It discusses the relationship of dimensional coordination to the metric conversion effort, its impact on the U.S. building regulatory system and illustrates some of the decisions these sectors need to make. It also discusses some of the organizational problems required to involve all segments of the industry in this decision-making process, and for implementing these decisions in a coordinated way on a national scale.

16557. Robertson, A. F., **Estimating smoke production from rooms and furnishings,** *Proc. Int. du Batiment (CIB) Symp. on the Control of Smoke Movement in Building Fires, Garston, U.K., Nov. 4-5, 1975,* pp. 21-32 (Conseil International du Batiment (CIB), Garston, U.K., 1975).

Key words: building materials; fires; optical density; room furnishings; smoke production; smoke tests.

In the absence of specific analytical methods for measuring the hazards of fire gases, there is a trend towards the use of smoke production as a partial measure of this hazard. It is suggested that present smoke test methods may be best used to provide indications of the possible smoke production, i.e., product of specific optical density and fire exposed area, characteristic of fully involved furnishing and interior finish products. It is demonstrated that very large quantities of smoke will result from combustion of only small quantities of most combustibles. Because of this there is little opportunity for elimination of the smoke hazard during fires through establishment of any but the most drastic limitations on the smoke development characteristics of materials considered acceptable. Measures for limiting ignition and development of fires, together with containment and disposal of smoke when fires occur, appear the most promising methods for reducing hazards due to smoke.

16558. Bennett, H. S., Forman, R. A., **Photoacoustic methods for measuring surface and bulk absorption coefficients in highly transparent materials: Theory of a gas cell,** *Appl. Opt.* **15,** No. 10, 2405-2413 (Oct. 1976).

Key words: bulk absorption coefficients; Fourier amplitudes; gas pressure; heat transfer; phase shifts; photoacoustic; surface absorption coefficients; transparent materials.

Researchers seek improved ways to measure the surface absorption and the bulk absorption coefficients of highly transparent materials. Procedures are presented here by which one may determine separately the surface absorption and the bulk absorption coefficients. For the case in which a laser beam modulated at angular frequency ω passes through the weakly absorbing windows of a gas cell containing a nonabsorbing gas, the temperature profiles in the cell windows and the temperature and acoustic pressure or stress profiles in the gas have been calculated. These calculations indicate that for sufficiently low frequencies and high ambient gas pressure, enough heat transfers from the cell windows to the gas to produce a detectable acoustic pressure signal at angular frequency ω in the gas. These calculations also enable us to state the necessary measurements for determining the surface and bulk absorption coefficients. Measuring the acoustic stress amplitude at the fundamental and higher harmonic frequencies and measuring the phase shifts of the frequency components of the acoustic stress with respect to the modulated laser beam give sufficient data by which one can determine the surface and bulk absorption coefficients. Numerical examples for a representative laser glass and air (nitrogen) are given.

16559. Holt, H. K., **Laser intracavity absorption,** *Phys. Rev. A* **14,** No. 5, 1901-1902 (Nov. 1976).

Key words: absorption; intracavity; laser; low density.

The fractional absorption which can be obtained using a single-mode laser with an internal absorption cell is compared to the fractional absorption obtainable with the more conventional system of a laser with an external absorption cell.

16560. Snyder, L. E., Hollis, J. M., Lovas, F. J., Ulich, B. L., **Detection, identification, and observations of interstellar $H^{13}CO^+$,** *Astrophys. J.* **209,** No. 1, 67-74 (Oct. 1, 1976).

Key words: formyl ion; interstellar molecules; microwave emission; molecular structure; radio astronomy; rotational spectrum.

Observations of interstellar $H^{13}CO^+$ are presented, and results of the molecular-structure computations supporting this particular molecular identification are given. Preliminary values of integrated intensity ratios of $H^{12}CO^+/H^{13}CO^+$ have been found for the main

HCO^+ clouds. Searches for $H^{12}C^{18}O^+$ were unsuccessful, and upper limits are given. U86.76, a new unidentified interstellar molecule which may be methylcyanoacetylene, was detected in Sgr B2.

16561. Boyne, H. S., **Laser power and energy measurements,** (Proc. Conf. Optical Design Problems in Laser Systems, San Diego, CA, Aug. 21-22, 1975), *SPIE* **69,** 90-94 (1975).

Key words: laser power and energy measurements; spatial response; temporal development.

Laser source and detector characterization necessary for laser systems design is reviewed. Power, energy and temporal development of sources are discussed. Also, the spatial response of detectors is addressed.

16562. Yaghjian, A. D., **A direct approach to the derivation of electric dyadic Green's functions,** *Proc. AP-S Int. Symp., University of Massachusetts, Amherst, MA, Oct. 11-15, 1976,* pp. 71-73 (Institute of Electrical and Electronics Engineers, New York, NY, Oct. 1976).

Key words: electromagnetic theory; Green's dyadic theory.

A straightforward yet rigorous approach that does not require distribution theory is used to derive a general electric dyadic Green's function which remains valid within the source region. Although the electric field expressed by the dyadic Green's function proves to be unique, the exact form of the dyadic itself depends upon the shape of its "principle volume." The dependence on principle volume is determined explicitly, and the different Green's dyadics derived by previous authors are shown to emerge merely through the appropriate choice for the principle volumes.

16563. Belsher, D. R., **Development of near-field electric energy density meter model EDM-2,** *HEW Publ. No. (NIOSH) 75-140,* 26 pages (U.S. Department of Health, Education, and Welfare, Cincinnati, OH, Mar. 1975).

Key words: electric energy density; energy density; near-field energy density.

The Occupational Safety and Health Administration (OSHA) Nonionizing Radiation Exposure Standard (29 CFE 1910.97, June 2, 1974) includes electromagnetic (E-M) radiation from 10 MHz to 100 GHz. However, no survey monitors presently are manufactured for making electric-field measurements of radiofrequency (rf) radiation from 10 to 300 MHz. Consequently, rf electric-field occupational exposure data cannot be collected until suitable monitoring instrumentation is available.

The relationship between the electric and magnetic fields is completely ambiguous for near-field surveys (within one wavelength of the source) of rf radiation sources. The electric and magnetic fields must be measured separately to obtain total occupational exposure. An electric-field survey monitor (EDM-2) was developed for the Physical Agents Branch, Division of Laboratories and Criteria Development, NIOSH, by the E-M Division, NBS to be used in assessing occupational exposure from industrial rf power sources.

The monitor employs a set of three orthogonal dipoles to obtain an essentially isotropic response. The dipoles are connected to the meter electronics by special high resistance conductors which have minimal interaction with the rf field. The meter displays electric energy density from 0.003 to 30 $\mu J/m^3$ which corresponds to plane-wave equivalent power density from 0.18 to 1800 mW/cm^2.

16564. Marshall, H. E., Ruegg, R. T., **Efficiency problems from user fees in municipal wastewater treatment,** *Water Resour. Bull.* **12,** No. 5, 903-917 (Oct. 1976).

Key words: cost sharing; economic efficiency; environment; equity; financing; grants; pollution abatement; user fees; wastewater; water pollution; water resources.

The Environmental Protection Agency administers a construction grant program to encourage abatement of wastewater pollution by sharing with municipalities the costs of wastewater treatment facilities. The enabling legislation (P.L. 92-500) specifies that EPA's cost share will be 75 percent of construction costs. It further requires municipalities to collect user fees from industrial users of the facilities to repay that part of the federal grant allocable to the treatment of industrial wastewater. The municipality must return half of the user fees collected to the U.S. Treasury; the municipality is allowed to retain the remaining half. Retention by municipalities of these user fees lowers their effective cost shares and results in the following consequences: (1) a bias for municipalities to select certain kinds of abatement techniques regardless of whether or not they are the least-cost techniques from the national perspective; (2) a bias for municipalities to select larger-than-optimal scales of abatement facilities; (3) a hidden federal subsidy to industry; and (4) grants that favor industrial communities. This article examines the legislative and regulatory requirements for user charges, derives the algebraic expressions for calculating the real federal, municipal, and industrial cost shares with user fees; computes municipal cost shares for selected values of the determinant factors; evaluates efficiency and other consequences of current user fee arrangements; and concludes that the efficiency distortions brought about by the impacts of user fees on cost sharing could be eliminated by requiring that all user fees collected from industry against the federal cost share be returned to the U.S. Treasury.

16565. Hubbard, C. R., Mighell, A. D., Staffa, J. A., Zervos, C., Konopelski, J. P., ***S*-carboxymethyl-L-cysteine sulfone,** *Acta Crystallogr.* **B32,** Part 9, 2723-2725 (Sept. 1976).

Key words: hydrogen bonding; single crystal; structure determination; *S*-carboxymethyl-L-cysteine sulfone; x-ray, zwitterion.

$C_5H_9SO_6N$, orthorhombic, $P2_12_12_1$; $a = 9.205$ (4), $b = 5.223$ (2), $c = 15.891$ (7) Å; $Z = 4$, $D_x = 1.836$, $D_m = 1.86$ (2) g cm^{-3} (flotation, 21 °C). The structure has been determined by direct methods and refined to an $R = 0.045$ for 944 independent reflections. The title compound exists as a zwitterion. Two carboxyl groups in adjacent molecules [O...O, 2.504 (5) Å] are involved in a strong hydrogen bond. The hydrogen atom was found to be covalently bonded to the carboxyl group in the carboxymethyl moiety.

16566. Siedle, A. R., Todd, L. J., **Chemistry of metalloborane derivatives containing the $B_{10}H_{12}$ ligand,** *Inorg. Chem.* **15,** No. 11, 2838-2842 (1976).

Key words: boron hydrides; deuterium; iridium; maleonitriledithiolate; metalloboranes; nuclear magnetic resonance; oxidative addition; palladium.

Ligand displacement reactions of $(B_{10}H_{12})Pd(PPh_3)_2$ were used to prepare $[(B_{10}H_{12})Pd(CN)_2]^{2-}$, $\{(B_{10}H_{12})Pd[C_2S_2(CN)_2]\}^{2-}$, and $(B_{10}H_{12})Pd(1,10\text{-}C_{10}H_8N_2)$. The reaction of the latter phenanthroline complex with butyllithium produced $\{[(B_{10}H_{11})Pd]_2C_{10}H_8N_2\}^{2-}$. The reaction of $C_2S_2(CN)_2^{2-}$ with $[(B_{10}H_{12})Ir(CO)(PPh_3)_2]$ led to $\{B_{10}H_{12})Ir(CO)\text{-}[C_2S_2(CN)_2](PPh_3)_2\}^-$ and $\{(B_{10}H_{12})Ir[C_2S_2(CN)_2](PPh_3)_2\}^-$. The reaction of $[(C_2H_5)_4N]$ $[(B_{10}H_{12})Ir(CO)(PPh_3)_2]$ in 1,2-$C_2H_4Cl_2$ with D_2 led to a regiospecific H-D exchange at the B(5,10) positions and the isolation of a $(B_{10}D_2H_{10})$ analogue. In CH_3CN solvent, exchange also took place at the bridge hydrogen positions. A mechanism for this reaction was proposed. Exchange of the carbonyl gruop in the iridaborance with ^{13}CO was observed.

16567. Engen, G. F., Hoer, C. A., **Application of an "arbitrary" 6-port junction to power measurement problems,** *Proc. 1972 CPEM Conf. on Precision Electromagnetic Measurements, Boulder, CO, June 26-29, 1972,* pp. 100-101 (Institute of Electrical and Electronics Engineers, New York, NY, 1972).

Key words: directional coupler; power detectors; sidearm power detector.

A directional coupler with a sidearm power detector is a well known form of power monitor. With the addition of a second coupler and detector as shown in figure 1 the "reflected" as well as the "incident" power may be measured.

16568. Engen, G. F., Hoer, C. A., **Application of an arbitrary 6-port junction to power-measurement problems,** *IEEE Trans. Instrum. Meas.* **IM-21,** No. 4, 470-474 (Nov. 1972).

Key words: power meter; 6-port junction.

An analysis of an arbitrary 6-port junction, four ports of which are terminated by power meters, shows that the net power input (or output) at either of the remaining ports is a linear function of the four power meter indications. The validity of this result has been experimentally demonstrated at 10 GHz. This device promises to be a useful tool in a wide variety of power measurement and calibration problems.

16569. Hellwig, H., **Clocks and measurements of time and frequency,** *Proc. 1976 WESCON, Session 32*, pp. 1-4 (Institute of Electrical and Electronics Engineers, New York, NY, Sept. 1976).

Key words: clocks; frequency and time; measurement of time and frequency; time and frequency.

After a brief historical review, the present state-of-the-art in frequency and time standards of high performance will be reviewed.

Precision oscillators used in precision time and time interval applications include quartz crystal, rubidium gas cell, cesium beam, and hydrogen maser oscillators. A general characterization and comparisons of these devices is given including accuracy, stability, availability, cost, etc. Areas of special concern in practical applications are identified and a projection of future performance is given. An attempt is made to predict physical and performance characteristics of new designs potentially available in the near future such as novel crystal standards, superconducting cavity devices, etc.

Methods for measuring frequency stability are discussed.

The methods employed for measuring frequency are designed to include state-of-the-art oscillators: they are fairly simple, and commonly available components can be used in the measurement systems.

Physical interpretations of common noise processes are discussed and it is shown how frequency domain stability characteristics may be translated to time domain stability characteristics.

A brief survey of the capabilities of available and potentially available time and frequency transfer techniques is given, including portable clocks, satellite methods, and radio broadcasts.

16570. Kimbleton, S. R., Wood, H. M., **A load leveling support methodology for networking,** *Proc. Winter Simulation Conf., National Bureau of Standards, Gaithersburg, MD, Dec. 6-8, 1976,* pp. 247-253 (Association for Computing Machinery, New York, NY, 1976).

Key words: computer networking; load leveling; resource sharing; scheduling.

Networking provides an effective means for resource sharing; however, its utility for load leveling requires further demonstration. This paper examines obstacles to load leveling and concludes that the key issues relate to the possible loss of control over remotely processed jobs and data. Although an organizational framework necessary to provide appropriate control exists, the technological support mechanism necessary for control in the form of processing guarantees has not yet been developed. Such development requires an essentially real time control capability for determining both the feasibility of accepting remote jobs as well as the guarantees which can be stipulated when such jobs are offered for processing. The key component of this capability is shown to be a very fast analytically driven simulation technique which can be invoked at a given site each time a job is offered for processing. We note in passing that this control capability can be viewed as the "other" side of control limits. That is, while control limits are concerned with determining when system performance has strayed out of bounds, a control capability is concerned with dynamic control of system workload to keep system performance within bounds.

16571. Sawyer, D. E., Berning, D. W., **Mapping nonlinearities over the active regions of semiconductor devices,** *Proc. IEEE Letters* **64,** No. 11, 1635-1637 (Nov. 1976).

Key words: device nonlinearity measurements; hot spots, transistor; laser scanning; nondestructive tests; semiconductor devices; UHF transistor measurements.

A laser scanner employing a modulated low-power 0.633-μm He-Ne laser has been used in a nondamaging manner to locate portions of a silicon bipolar UHF transistor which electrically behave in a nonlinear manner at a signal frequency of 470 MHz. In effect, the method uses the device scanned as a frequency converter to produce an IF output for a display screen whenever the laser spot is incident on nonlinear regions.

16572. Hogan, P. B., Carlsten, J. L., Pichanick, F. M. J., Smith, S. J., Smith, W. W., **Spontaneous Raman processes in multiphoton excitation of sodium,** *Phys. Rev. Lett.* **37,** No. 15, 990-993 (Oct. 11, 1976).

Key words: atomic beams; multiphoton ionization; sodium; spontaneous Raman scattering in free atoms.

We have observed spontaneous Raman processes in a sodium atomic beam. When one sodium $3p\ ^2P$ fine-structure level is strongly excited by a dye laser, the other level is weakly populated by spontaneous Raman emission and the absorption of another laser photon. This effect is detected by further stepwise excitation plus photoionization. The observed magnitude agrees well with theory. This technique is much more sensitive than methods involving direct observation of the Raman emission.

16573. Corliss, E. L. R., Jones, F. E., **Method for estimating the audibility and effective loudness of sirens and speech in automobiles,** *J. Acoust. Soc. Am.* **60,** No. 5, 1126-1131 (Nov. 1976).

Key words: alarm signals; hearing; loudness functions; masking; sirens; speech recognition; traffic noise.

By using the parameters for the ear and the equations for a "communication theory" model of the behavior of the ear, a family of masking curves can be drawn up which one can apply to the conditions prevalent in automotive vehicles. From the behavior of the ear and its ability to resolve sounds in noise, estimates can be made of the conditions under which sirens and speech communications will be audible within motor vehicles moving in traffic, and some estimate can also be made as to their potential for attracting notice. These quantities can be read off by graphic techniques. Examples of their use are given.

16574. Mayo, S., Keller, R. A., Travis, J. C., Green, R. B., **Detection of sodium trace contamination in furnace atmospheres at 1000 °C,** *J. Appl. Phys.* **47,** No. 9, 4012-4016 (Sept. 1976).

Key words: dye laser use for resonance fluorescence; furnace atmosphere sodium contamination; furnace qualification; resonance fluorescence; sodium trace detection.

Free sodium atoms were detected by resonance fluorescence in an open contaminated quartz tube heated to 1000 °C. The quartz tube

and furnace were similar to those used in semiconductor device processing. Fluorescence was excited by a cw dye laser tuned to the sodium D_1 or D_2 transition and directed along the axis of the furnace. Fluorescence from the sodium D_2 line emitted in the axial direction was collected by a telescopic system and focused onto a photomultiplier tube. The estimated minimum detectable sodium density in the furnace is 5×10^6 atoms/cm^3. No free sodium was detectable on a processing tube that had not been intentionally contaminated.

16575. Engen, G. F., **Calibration of an arbitrary six-port junction for measurement of active and passive circuit parameters,** *IEEE Trans. Instrum. Meas.* **IM-22,** No. 4, 295-299 (Dec. 1973).

Key words: circuit parameters; networks; six-port.

It has been recently recognized that an arbitrary six-port junction, four arms of which are terminated in power meters, can be calibrated to measure the circuit parameters, v, i, z, a, b, Γ, etc., in addition to power. Because this scheme eliminates the need for frequency conversion, it provides a substantially simplified approach to the design of an automatic network analyzer. This paper outlines a calibration procedure for the six-port which is only slightly more complicated than that in use for existing automated measurement systems.

16576. Cotton, I. W., **New family of standards being developed,** *Computerworld,* pp. S/2-S/22 (Nov. 29, 1976).

Key words: computer networks; data communications; data networks; networks; packet switching; protocol; standards.

Recent developments in data network standards are briefly surveyed, including developments in call establishment, data link control, and packet switching.

16577. Sawyer, D. E., Berning, D. W., **Thermal mapping of transistors with a laser scanner,** *Proc. IEEE Letters* **64,** No. 11, 1634-1635 (Nov. 1976).

Key words: active devices; hot-spot behavior; laser scanning; nondestructive testing; silicon optical absorption coefficient; temperature mapping.

An active near-infrared laser scanner has been used to electronically map the temperature variations over the active regions of silicon interdigitated UHF transistors operating in the hot-spot regime. The principle makes use of the increase in electron-hole pair generation by the absorbed laser light with increasing temperature. The regions of enhanced photoresponse are displayed on a cathode-ray-tube display screen. Extensions to other devices and operating conditions, other than those which result in hot-spot operation, are suggested.

16578. Kuyatt, C. E., Mielczarek, S. R., Weiss, M. J., **Intensities of infrared transitions in N_2O and H_2CO by electron impact spectroscopy,** *J. Chem. Phys.* **65,** No. 9, 3481-3485 (Nov. 1, 1976).

Key words: H_2CO; inelastic electron scattering; infrared transitions; N_2O; relative intensities.

Measurements of relative intensities of infrared transitions in N_2O and H_2CO have been made using forward inelastic scattering of 100 eV electrons. Agreement with previous infrared and electron impact measurements is satisfactory, showing that infrared intensities can be obtained from electron scattering measurements without the need for pressure broadening or corrections for the spectrometer slitwidth.

16579. Browne, J. C., Lamaze, G. P., Schröder, I. G., **Ratio of neutron capture cross sections for ^{186}Os and ^{187}Os at 25-keV neutron energy,** *Phys. Rev. C* **14,** No. 3, 1287-1288 (Sept. 1976).

Key words: $E_n = 25$ keV; measured cross-section ratio; nuclear reactions; ^{186,187}Os(n,γ).

The ratio of the neutron capture cross sections for ^{186}Os and ^{187}Os was measured at the 25-keV iron-filtered neutron beam facility of a 10-MW reactor. A value of 0.41 ± 0.04 was obtained. Using this ratio, the age of the universe was determined via the Re-Os β-decay clock to be approximately 19×10^9 years.

16580. Baldwin, E. E., **Voltage-controlled attenuator has minimum phase shift,** *EDN/EEE,* p. 40 (Nov. 5, 1971).

Key words: FET; pi network; tank circuit.

A FET in a pi network makes a good attenuator at a specific radio frequency, but gives variable phase shift with changing attenuation. A tank circuit across source-drain leads solves the problem.

16581. Herbst, J. F., Watson, R. E., Lindgren, I., **Coulomb term U and 5f electron excitation energies for the metals actinium to berkelium,** *Phys. Rev. B* **14,** No. 8, 3265-3272 (Oct. 15, 1976).

Key words: actinium; excitation energy; U; 5f electron.

Relativistic Hartree-Fock-Wigner-Seitz band calculations have been performed for the actinide metals Ac through Bk in order to estimate the Coulomb term U and 5f electron excitation energies. Our calculations predict that the tetravalent state (four 6d-7s conduction electrons) is stable relative to the trivalent state for the lighter elements and that near uranium relative stabilization of the trivalent state occurs. We find that U increases from 2-3 eV for Th to 4-5 eV for the heavier elements considered. 5f level widths W are estimated and found to decrease from 2 to 1/2 eV; together with the results for U this points to progressive localization of the 5f states. The ratio U/W, which is most indicative of localization, takes on values intermediate between those for 3d and 4f electrons.

16582. Altschuler, H. M., **1. Commission I and the General Assembly. 2. The General Assembly as an open symposium,** *URSI Inf. Bull. No. 190,* 10-15 (Mar. 1974).

Key words: general assembly; open symposium.

The place of Commission 1 in the world of standards of physical measurements and whether or not the scientific programme at the General Assembly of Commission 1, as well as all other Commissions should be converted into an open Symposium are discussed in the paper.

16583. Kostkowski, H. J., **Uncertainties in the measurement of incoherent optical radiation,** *Proc. Symp. on Biological Effects and Measurement of Light Sources, Rockville, MD, Mar. 25-26, 1976,* pp. 107-114 (HEW, PHS, Food and Drug Administration, Bureau of Radiological Health, Rockville, MD, Oct. 1976).

Key words: accuracy; optical radiation measurement; radiometry; systematic errors; uncertainties.

Uncertainties for state-of-the-art measurements of incoherent optical radiation are about 1 percent. Uncertainties for measurements made under less than ideal conditions are considerably larger. The major reasons for these uncertainties and what is being done and can be done to reduce them are presented.

16584. Suenram, R. D., Johnson, D. R., Glasgow, L. C., Meakin, P. Z., **Laboratory microwave spectrum of $ClONO_2$,** *Geophys. Res. Lett.* **3,** No. 10, 611-614 (Oct. 1976).

Key words: atmospheric pollution; chlorine nitrate; dipole moment; microwave spectrum; ozone depletion; rotational constants; stratospheric chemistry.

The microwave spectrum of $ClONO_2$ has been analyzed in the laboratory under high resolution. Rotational constants are reported for the ground and lowest vibrational states of the ^{35}Cl and ^{37}Cl isotopic forms. From Stark effect measurements the electric dipole moment was found to have components along two principal axes, $\mu_a = 0.72 \pm 0.10$ Debye and $\mu_b = 0.28 \pm 0.04$ Debye. Difficulties encoun-

tered in handling gas phase samples of $ClONO_2$ are discussed in some detail.

16585. Siedle, A. R., **Organometallic derivatives of trithiones,** *J. Organomet. Chem.* **120,** 369-374 (Apr. 1976).

Key words: carbon-13 NMR; coordination compounds; metal carbonyl; thiocarbonyl; 1,3-dithiolane-2-thione; 1,3-dithiolene-2-thione.

Complexes of the type $LM(CO)_5$ (M = Cr, Mo) were prepared from (diolefin)$M(CO)_4$ and the 1,3-dithiolene-2-thione ligands, L = $C_3H_2S_3$, $C_3H_4S_3$ and $C_8H_6S_3$. Infrared, ^1H and ^{13}C NMR data indicated C_{4v} symmetry about the metal centre. The reaction of 3-methylbenzo-1,3-dithiolene-2-thione with $(C_5H_5)Co(C_8H_{12})$ produced a cobalt(III) methylbenzothiete derivative $(C_7H_6S_2)$-$Co(C_5H_5)$.

16586. Bowen, R. R., Reed, L. E., **Semiporous reinforcing fillers for composite resins: II. Heat treatments and etching characteristics,** *J. Dent. Res.* **55,** No. 5, 748-756 (Sept.-Oct. 1976).

Key words: composite resins; composites; dental materials; fillers; porous glass; radiopacity; reinforcements; wear.

Candidate experimental semiporous reinforcing filler particles were prepared by heat treatment of certain glass compositions, followed by crushing and etching. Optical microscopic techniques were aided by the use of certain dyes and staining procedures to manifest submicroscopic interconnected porosity in the surface of the particles. The goal of this endeavor was to develop semiporous glass reinforcing fillers for the improvement of dental composite materials.

16587. Bowen, R. L., Reed, L. E., **Semiporous reinforcing fillers for composite resins: I. Preparation of provisional glass formulations,** *J. Dent. Res.* **55,** No. 5, 738-747 (Sept.-Oct. 1976).

Key words: composite resins; composites; dental materials; fillers; porous glass; radiopacity; reinforcements; wear.

A conceptual means of obtaining improved bonding between filler particles and the polymeric binders of composites is presented. It involves preparing glass particles that separate into two interconnected vitreous phases when heated to an appropriate temperature, and then etching these to produce a porous surface layer. Candidate glass compositions were prepared and subjected to heat treatment in a gradient furnace. Compositions susceptible to phase separations were delineated.

16588. Phaneuf, R. A., Taylor, P. O., Dunn, G. H., **Absolute cross sections for emission of 284.7-nm (Hg II) and 479.7-nm (Hg III) radiation in electron-mercury-ion collisions,** *Phys. Rev. A* **14,** No. 6, 2021-2025 (Dec. 1976).

Key words: absolute cross sections; electron impact; mercury ions; 285-nm radiation; 480-nm radiation.

Crossed beams of electrons and Hg^+ ions have been used to measure absolute cross sections for emission of 284.7-nm radiation, resulting from excitation of a predominantly ground-state Hg^+ target to the $7s^2S_{1/2}$ state. Values range from 3×10^{-17} cm^2 near threshold, where the cross section is strongly peaked, to 1.3×10^{-18} cm^2 at 280 eV. Also reported are some measurements of emission of 479.7-nm (Hg III) radiation, resulting from electron impact on both Hg^+ and Hg^{++} targets. Cross sections range from approximately 5×10^{-19} to 5×10^{-20} cm^2, and in the case of electron-Hg^{++} collisions, are more than an order of magnitude smaller than predicted by an available semiclassical binary-encounter calculation.

16589. Tsai, D. H., MacDonald, R. A., **Molecular-dynamical study of second sound in a solid excited by a strong heat pulse,** *Phys. Rev. B* **14,** No. 10, 4714-4723 (Nov. 15, 1976).

Key words: anharmonic crystal; computer simulation; energy transport; heat pulse; molecular dynamics; second sound; stress pulse; temperature wave; thermal diffusivity; thermal equilibrium; thermal relaxation.

We use the method of molecular dynamics to study the problem of heat transfer in a perfect semi-infinite bcc lattice when a strong heat pulse is applied at the boundary. We find that the disturbance propagates into the lattice as a combination of first sound and second sound superimposed on a diffusive background. The second-sound wave is a composite of several waves. We are able to show that the longitudinal and transverse sound waves, traveling with velocity C_l and C_s, respectively, are generated by the disturbance when the boundary of the lattice is rapidly heated or cooled. These stress-induced pulses are not in thermal equilibrium but they generate their own temperature waves, which travel with velocities $C_l/\sqrt{3}$ and $C_s/\sqrt{3}$, and which contribute to the observed second-sound wave. The disturbance in kinetic energy produced during the period of steady heating in the pulse propagates as a temperature wave with the theoretically expected second-sound velocity, $C_{ar}/\sqrt{3}$. We relate these results to theoretical and experimental work on second sound excited by a weak pulse and also to our earlier calculations where the temperature wave is excited by shock compression.

16590. Stockbauer, R., Inghram, M. G., **The fragmentation of propane and deuteropropane molecular ions,** *J. Chem. Phys.* **65,** No. 10, 4081-4092 (Nov. 15, 1976).

Key words: coincidence; mass spectrometry; photoionization; propane; propane-d_2; propane-d_6; propane-d_8; threshold photoelectron spectroscopy.

Fragmentation of molecular ions as a function of internal energy has been studied for the propane molecules, C_3H_8, $CH_3CD_2CH_3$, $CD_3CH_2CD_3$, and C_3D_8 using threshold photoelectron-photoion coincidence mass spectrometry. Within the energy range covered (0-6 eV internal energy) the experimental fragmentation curves are compared with those calculated using the quasiequilibrium theory. The general features of the experimental curves are reproduced by the calculations but significant deviations from exact calculations are apparent. The experimental curves for the d_2 and d_6 propanes show that hydrogen scrambling processes occur and are of sufficient importance that they must be included in future calculations.

16591. Truhlar, D. G., Wyatt, R. E., **History of H_3 kinetics,** *Ann. Rev. Phys. Chem.* **27,** 1-43 (1976).

Key words: chemical reactions; collision theory; cross sections; dissociation; hot atoms; isotope effects; kinetics; molecular beams; quantum mechanics; rate coefficients; recombinations; scattering theory.

The gas-phase reaction of H with H_2 has been of fundamental interest since London (1929) pointed out that it can be understood in terms of a potential energy surface calculated from quantum mechanics. It has also been the only gas-phase bimolecular reaction for which curvature of the Arrhenius plot could be observed at low temperature (Marshall and Purnell 1968). Thus it served as a model for theories of tunneling. Because every atom involved can be substituted by D or T, it has been an important prototype system for isotope effect considerations. Because good photochemical and nuclear recoil sources of hot (i.e., fast) H, D, or T atoms are available, it has also been studied under nonthermal high-energy conditions (Rowland 1970). In addition it has been extensively studied by classical and quantum mechanical collision theory.

16592. Bowman, R. R., **Quantifying hazardous electromagnetic microwave fields: Practical considerations,** *Proc. Biological Effects and Health Implications of Microwave Radiation, Richmond, VA, Sept. 17-19, 1969, BRH/DBE 70-2,* 204-209 (U.S. Dept. of Health, Education, and Welfare, Rockville, MD, June 1970).

Key words: electromagnetic microwave fields.

This paper is concerned mainly with the problem of making easy, reasonably accurate survey measurements of hazardous EM fields. For general survey use, instruments should be rugged, easy-to-use, and should be capable of fast response as well as having long-term averaging capabilities. These, and other considerations to be discussed, place restrictions on practical instrument designs for general survey use.

16593. Duff, J. W., Truhlar, D. G., **Classical *S* matrix: Application to classically forbidden vibrational excitation for He + HBr and H + Br_2,** *Chem. Phys.* **17,** 249-254 (Oct. 1976).

Key words: classical scattering matrix theory; collision theory; scattering theory; trajectories.

The integral expressions of classical *S* matrix theory are tested against quantum mechanical results and classical path-forced quantum oscillator results for vibrational transition probabilities in collinear collisions of atoms with harmonic and Morse vibrators for the H + Br_2 and He + HBr mass combinations. The interaction potential is assumed to be a repulsive exponential function. The energy range studied (in units of $\hbar\omega_e$) is 2-10 for H + Br_2 and 2-6 for He + HBr. The integral expressions are found to be accurate within a factor of two for almost all transition probabilities greater than 7×10^{-3} but to be very inaccurate for very small transition probabilities. Quasiclassical trajectory histogram methods are found to be accurate within a factor of two only for transition probabilities greater than 0.15. Neither the integral expressions of classical *S* matrix theory nor the quasiclassical trajectory histogram method are found to be as generally accurate as the classical path-forced quantum oscillator results.

16594. Green, R. B., Travis, J. C., Keller, R. A., **Resonance flame atomic fluorescence spectrometry with continuous wave dye laser excitation,** *Anal. Chem.* **48,** No. 13, 1954-1959 (Nov. 1976).

Key words: atomic flame fluorescence; barium fluorescence; cw dye laser; sodium fluorescence.

The potential contribution of continuous wave (CW) dye laser excitation of resonance atomic fluorescence for analytical flame spectrometry was evaluated. Noise sources which were related to fluctuations in the flame and in the laser scatter were responsible for the observed detection limits which were an improvement over those achieved with previously used excitation sources for flame atomic fluorescence and comparable to results for flame emission spectrometry. Based on experimental data, it was estimated that continuous wave excitation powers of 1-10 watts would be sufficient to bring the signal-to-noise ratio into a constant range. With the exception of nonresonant detection and saturation contributions to reduced quenching, higher laser powers common to pulsed sources are of no advantage and, in fact, are detrimental to sensitivity. Other aspects of CW dye laser excitation are presented and discussed.

16595. Haus, J. W., Meijer, P. H. E., **Static aspects of a model for metastable fluid states,** *Physica Letter to the Editor* **80A,** No. 3, 313-317 (1975).

Key words: limit of stability; mean field theory; metastability; perturbation scheme; reference system; structure factor.

A mean field-theory originally presented by Brout is used to obtain the limit of (meta-) stability for a Lennard-Jones system. Certain aspects of the theory are discussed in relation to recent results for liquid-solid phase transitions.

16596. Julienne, P. S., $^3\Sigma_u^-$-$^3\Sigma_u^+$ **coupling in the O_2 $B^3\Sigma_u^-$ predissociation,** *J. Mol. Spectrosc.* **63,** 60-79 (1976).

Key words: molecular oxygen; predissociation; Schumann-Runge bands; spin-orbit mixing.

The role of $B^3\Sigma_u^-$-$2^3\Sigma_u^+$ spin-orbit mixing in the O_2 Schumann-Runge predissociation is investigated. The $2^3\Sigma_u^+$ state is found to cross the $B^3\Sigma_u^-$ state near 2.0 Å with an interaction matrix element of approximately 55 cm^{-1}. This state contributes to the widths of the *B* $v \geq 6$ levels, but introduces only small level shift perturbations. When the partial widths due to the $^3\Sigma_u^-$-$^3\Sigma_u^+$ interaction are added to the previously calculated widths due to the $^5\Pi_u$, $^3\Pi_u$, and $^1\Pi_u$ states, reasonable agreement is obtained with experimental measurements on $O^{16}O^{16}$ and $O^{18}O^{18}$. The possibility of non-Lorentzian line profiles and the dependence of the width on rotational quantum number is investigated. The approximation of the spin-orbit matrix element by its value at the crossing point is shown to be a good approximation for calculating the second difference perturbations.

16597. Swartzendruber, L. J., Bennett, L. H., Watson, R. E., **Mössbauer studies of hydrided TiFe,** *J. Phys. F: Metal Phys. Letter to the Editor* **6,** No. 12, L331-L334 (1976).

Key words: charge flow; isomer; Mössbauer; phase diagram; $TiFeH_x$ alloys; volume effects.

The metallurgical and electronic structure of $TiFeH_x$ alloys are probed by ^{57}Fe Mössbauer effect studies. Our results are qualitatively consistent with and support Reilly and Wiswall's conclusions on the phase diagram. Volume effects and charge flow are both important in the isomer shift.

16598. Lias, S. G., Ausloos, P., **Reactions of CCl_2H^+ and CF_2H^+ with organic and inorganic compounds: proton affinities and heats of formation of CCl_2 and CF_2,** *Int. J. Mass Spectrom. Ion Phys.* **22,** 135-145 (1976).

Key words: CCl_2, CF_2; CCl_2H^+, CF_2H^+; displacement reactions; four-center reactions; ion molecule reactions; proton affinity; proton transfer; rate coefficients.

The reactions of CCl_2H^+ (or CCl_2D^+) and CF_2H^+ with a number of aldehydes, ketones, esters, organic acids, alcohols, amines and inorganic compounds have been observed. Since the proton affinities of most of these compounds are known, it was possible on the basis of the observation or nonobservation of proton transfer reactions to obtain proton affinities for CF_2 and CCl_2 of 7.74 ± 0.04 eV (178.6 ± 1 kcal $mole^{-1}$) and 8.69 ± 0.06 eV (200.4 ± 1.5 kcal $mole^{-1}$), respectively. In addition to proton transfer, CCl_2H^+ and CF_2H^+ undergo reactions with carbonyl-containing compounds entirely analogous to those which have been observed for other halomethyl ions. That is, with aldehyde and ketone reactants, four-center reactions resulting in the formation of a mono-halogenated carbonium ion are the major competing processes, and with esters and acids elimination reactions and four-center reactions resulting from attack by the ion at the acyl oxygen are important. These ions also displace carbonium ions from alcohols, and abstract hydride ions from esters and amines. Charge transfer is an important competing channel in reactions with amines.

16599. Richmond, J. C., **Image quality of photoelectronic imaging systems and its evaluation,** (Proc. 6th Symp. on Photo-Electronic Image Devices, London, England, Sept. 9-13, 1974), Paper in *Advances in Electronics and Electron Physics*, L. Marton, Ed., **40B,** 519-538 (Academic Press, New York, NY, 1976).

Key words: blooming; contrast transfer function; distortion; flare; image quality; light induced background; limiting resolution; night vision devices; optical transfer function; resolution charts; veiling glare.

Image quality is probably the single most important parameter in determining the usefulness of any optical device. For night vision systems in particular, image quality is of paramount importance. Subjective evaluation of image quality is surprisingly good. An observer will have no difficulty in ranking a number of photographs in order of overall image quality. The general agreement between different observers on the order of ranking of the same series of photo-

graphs will also be good. However, objective evaluation of image quality in quantitative terms is not easy. Many variables contribute to image quality, not all of which have been identified, or can be quantitatively evaluated. This paper is primarily a literature survey of criteria and techniques that have been used to evaluate the quality of imaging systems, with some discussion of their application to image intensifier night vision devices.

16600. Wiederhorn, S. M., Roberts, D. E., **A technique to investigate high temperature erosion of refractories,** *Bull. Am. Ceram. Soc.* **55,** No. 2, 185-189 (1976).

Key words: castable refractories; coal gasification; deformation; erosion; fracture; wear.

A description is given of equipment used to study erosion of refractories under controlled environments at temperatures as high as 1500 °C. Erosive wear of a high alumina castable refractory currently used in coal gasification pilot plants is investigated. Erosion occurs preferentially in the cement matrix of the refractory. At 25 °C erosion occurs by brittle fracture of the matrix, while at 1000 °C, erosion occurs by fracture and shear deformation of the matrix phase. Data are discussed with reference to current theories of erosion.

16601. Haus, J. W., Meijer, P. H. E., **Dynamics of metastable fluid states in the liquid-solid transition,** *Phys. Rev. A* **14,** No. 6, 2285-2294 (Dec. 1976).

Key words: hydrodynamic regime; ideal gas memory function; limit of stability; metastable fluid states; nonhydrodynamic regime; relaxation time; transport coefficients; Zwanzig-Mori formalism.

A fluctuation theory for the dynamics of metastable fluid states is presented which relies on a limiting form for the static structure factor $S(k)$ previously presented by the authors. The transport coefficients are found to show a divergence in the hydrodynamic regime. In the nonhydrodynamic regime a model is presented which uses an approximate single-particle memory function and a diffusive mode is found; this is compared with fluctuation theory results of other workers. A recent computer experiment has shown numerical agreement with the static model.

16602. Simmons, J. A., Clough, R. B., **Theoretical aspects of acoustic emission spectral measurements,** *Proc. Eighth World Conf. on Nondestructive Testing, Cannes, France, Sept. 6-10, 1976,* pp. 1-8 (Imprimplans, Paris, France, 1976).

Key words: acoustic emission; dislocations; nondestructive evaluation; spectral analysis.

Frequency spectrum analysis of acoustic emission signals shows great promise as a nondestructive test method. It has potential for discriminating between harmful moving defects and system noise as well as for revealing more of defect characteristics than are currently revealed with threshold counting techniques. However, such an analysis required a systematic examination of the entire emission process.

In this paper, we describe progress in developing the theory of acoustic emission. More specifically, we examine acoustic emission from planar, straight line dislocation segments moving in bursts. For simplicity, we will for the present treat the ideal case of an infinite isotropic body. This case should, however, provide an illustration of the general nature of the acoustic emission spectrum and how it is produced.

16603. Hall, J. L., Bordé, C. J., Uehara, K., **Direct optical resolution of the recoil effect using saturated absorption spectroscopy,** *Phys. Rev. Lett.* **37,** No. 20, 1339-1342 (Nov. 15, 1976).

Key words: CH_4 hyperfine structure; high resolution spectroscopy; laser spectroscopy; line shape; optical frequency standards; recoil effect; relativity.

The recoil-induced spectral doubling of the CH_4 saturated absorption peaks at 3.39 μm has been clearly resolved. A working resolving power of 8×10^{10} (1 kHz half width at half-maximum), achieved with aberration-compensated parabolic optics of 32 cm diam, was available to study the height ratio and splitting of the recoil peaks. The resolved Doppler-generated level crossings are not recoil doubled and give improved hfs information. We derive new, exact equations relating the atomic natural frequency to laboratory resonance frequencies.

16604. Green, R. B., Keller, R. A., Luther, G. G., Schenck, P. K., Travis, J. C., **Galvanic detection of optical absorptions in a gas discharge,** *Appl. Phys. Lett.* **29,** No. 11, 727-729 (Dec. 1, 1976).

Key words: discharge; discharge tubes; hollow cathode; spectroscopy; trace detection; tunable lasers.

An electrical signal, resulting from discrete optical absorptions, has been observed for a variety of elements, including several for which such an effect had not been previously reported. In the present case, the effect is observed as a change in the voltage across a gas discharge tube produced by irradiation with a laser tuned to the wavelength of a transition of a species in the discharge. This signal may be used—without optical detection apparatus—for spectroscopic investigations or analytical determinations of materials in the discharge. Signals were obtained for transitions of lithium, sodium, calcium, barium, uranium, neon, and helium, in commercial hollow cathode lamps, and neon and helium in conventional discharge tubes.

16605. Latour, J., Spiegel, E. A., Toomre, J., Zahn, J. P., **Stellar convection theory. I. The anelastic modal equations,** *Astrophys. J.* **207,** No. 1, 233-243 (July 1, 1976).

Key words: convection theory; convection zones; stellar structures.

We present here a system of equations for stellar convection theory. These equations follow from the full equations of compressible fluid dynamics with the introduction of two important approximations. The first of these is the anelastic approximation, commonly used in meteorology. Its aim is to filter out acoustic waves so that the task of numerical solution will not be complicated by the need to resolve very rapid time variations. The anelastic approximation is justified when the frequencies and Mach numbers of the convection are not too high. Its basic effect is to suppress terms which are nonlinear in the horizontal fluctuations of the thermodynamic variables, but it allows large vertical variation in the mean density and preserves the dynamical nonlinearities. The second approximation is a drastic simplification of the horizontal structure of the convection. It consists of expanding the fluctuating quantities in a set of modes which are periodic in the horizontal coordinates, and then truncating after a few terms.

The resulting system of nonlinear partial differential equations (in vertical coordinate and time) is still formidable, and its numerical resolution has so far been achieved only for relatively simple cases of stellar convection, to be presented in subsequent papers. These anelastic modal equations can also be used to treat more complicated problems such as semiconvection and the coupling of convection to radial pulsation or rotation.

16606. Toomre, J., Zahn, J. P., Latour, J., Spiegel, E. A., **Stellar convection theory. II. Single-mode study of the second convection zone in an A-type star,** *Astrophys. J.* **207,** No. 2, 545-563 (July 15, 1976).

Key words: A-type stars; convection theory; convection zones; metallic-line stars; stellar structure.

The anelastic modal equations presented in Paper I are considered in their simplest version: only one mode is retained in the representation of the fluctuating dynamic and thermodynamic variables of con-

vection theory. These single-mode equations are used to examine the structure of the second convection zone of an A-type star. Two- and three-dimensional numerical solutions are obtained for a range of parameters in the theory, and a simple analysis is provided for their interpretation.

The principal results are for three-dimensional motions, since these are most likely to be relevant to stellar convection. Such motions produce a convective heat flux several orders of magnitude greater than predicted by standard mixing-length theory for the same situation; we find that convection carries up to 6 percent of the total flux. The most significant astrophysical implication of our results is that they suggest strong overshooting into the adjacent radiative zones. We anticipate that mixing will extend to the overlying hydrogen convection zone. This would rule out some interpretations of metallic-line stars which invoke diffusive element separation between the two convection zones.

16607. Truhlar, D. G., **Quasiclassical predictions of final vibrational state distributions in reactive and nonreactive collisions,** *Int. J. Quant. Chem. Symp.* **10,** 239-250 (1976).

Key words: chemical reactions; classical probability matrix theory; classical scattering matrix theory; collision theory; energy transfer in collisions; hydrogen molecules; information theory; scattering theory; trajectories; vibrational energy.

The validity of quasiclassical and semiclassical trajectory methods for predicting state-to-state vibrational transition probabilities in collisions of atoms with diatomic molecules is discussed with special emphasis on tests against accurate quantum calculations for $He + H_2$, $H + Cl_2$, and $I + H_2$ collisions.

16608. Norcross, D. W., Seaton, M. J., **Energy levels for Be I calculated using a model potential and cores approximation,** *J. Phys. B* **9,** No. 17, 2983-3000 (Dec. 1976).

Key words: Be energy levels; model potential theory.

A two electron model Hamiltonian, used for Be I, includes a core polarization potential $V_{POL}(1,2)$ which has asymptotic form $V_{POL} \sim -\alpha\{(r_1/r_1^2)+(r_2/r_2^2)\}^2$ where α is the polarizability of Be III $1s^2$. Solutions are obtained using a frozen cores method. Two approximations are considered: (a) uses an expansion with core states Be II 2s and 2p; (b) includes in addition a 3d core orbital with a parameter determined variationally. For the series ^1S, ^3S, $^1P^o$, $^3P^o$, ^1D, ^3D, $^1F^o$ and $^3F^o$ results are obtained for all bound states ($\epsilon < 0$) with $n_e \leq 10$, for $n = \infty$ ($\epsilon = 0$), and for the first resonances states in the region $\epsilon > 0$. For the series ^1P, ^3P, $^1D^o$, $^3D^o$ converging to Be II 2p, results are obtained for $n \leq 10$ and for $n = \infty$. The calculated ionization energies are more accurate than those obtained in previous theoretical work.

16609. Avrett, E. H., Vernazza, J. E., Linsky, J. L., **Excitation and ionization of helium in the solar atmosphere,** *Astrophys. J.* **207,** No. 3, L199-L204 (Aug. 1, 1976).

Key words: helium; radiative transfer; solar chromosphere; spectral line formation.

We investigate the excitation and ionization of He I and He II for the case of a realistic solar model. The calculations are based on a simplified numerical treatment of the He I and He II continua and the He II λ304 line. We discuss the extent to which various proposed mechanisms can account for the observed line and continuum intensities.

16610. Hall, J. L., Bordé, C. J., **Shift and broadening of saturated absorption resonances due to curvature of the laser wave fronts,** *Appl. Phys. Lett.* **29,** No. 12, 788-790 (Dec. 15, 1976).

Key words: lineshape theory; optical frequency standards; saturated absorption spectroscopy.

Using frequency offset-locked spectroscopy of methane at 3.39 μm we show that the saturated absorption peaks can be significantly blue or red shifted if the wave fronts of the laser beam are spherical in the gas cell. Good agreement with theoretical prediction is found. We discuss suitable conditions to avoid this geometry-induced shift in optical frequency standards.

16611. Kahn, L. R., Baybutt, P., Truhlar, D. G., *Ab initio* **effective core potentials: Reduction of all-electron molecular structure calculations to calculations involving only valence electrons,** *J. Chem. Phys.* **65,** No. 10, 3826-3853 (Nov. 15, 1976).

Key words: basis functions; configuration mixing; dipole moments; electronic structure of molecules; Hartree-Fock; integrals, evaluation of; molecular structure; orbitals; potential energy curves; pseudopotentials; self-consistent field; valence electrons.

A formalism is developed for obtaining *ab initio* effective core potentials from numerical Hartree-Fock wavefunctions and such potentials are presented for C, N, O, F, Cl, Fe, Br, and I. The effective core potentials enable one to eliminate the core electrons and the associated orthogonality constraints from electronic structure calculations on atoms and molecules. The effective core potentials are angular momentum dependent, basis set independent, and stable against variational collapse of their eigenfunctions to core functions. They are derived from neutral atom wavefunctions using a pseudo-orbital transformation which is motivated by considerations of the expected accuracy of their use and of basis set economy in molecular calculations. Then the accuracy is demonstrated by multiconfiguration Hartree-Fock calculations of potential energy curves for HF, HCl, HBr, HI, F_2, Cl_2, Br_2, and I_2 and one-electron properties for HF and HBr. The differences between valence-electron calculations employing the present effective core potentials and all-electron calculations are smaller than differences due to basis set choices, even though the basis sets are extended ones. Thus the effective core potentials are quite successful. In addition larger configuration mixing calculations are performed for HBr and Br_2 (1637 and 3396 configurations, respectively) and again the effective core potentials are judged to perform well.

16612. Richards, J. L., Johnson, P. M., **The visible emissions of molecular oxygen in rare gas solids,** *J. Chem. Phys.* **65,** No. 10, 3948-3951 (Nov. 15, 1976).

Key words: emission spectra; intersystem crossing; molecular oxygen in rare gas solids; O_2 excited states.

The vacuum ultraviolet-excited emission spectra of molecular oxygen in low temperature rare gas solids have been recorded and analyzed. The observed transitions have been reassigned using isotopic substitution and are found to be $C^3\Delta_u \rightarrow X^3\Sigma_g^-$ in argon and krypton and $c^1\Sigma_u^- \rightarrow a^1\Delta_g$ in xenon. These transitions have not been observed in the gas phase and the transition origins established here confirm previous tentative assignments of vibrational numberings of the upper states by Herzberg and Degan, respectively. The emission in xenon is very unusual for a solid phase spectrum in that emission occurs from several excited vibrational levels, which are apparently being populated directly by intersystem crossing. It is also unusual in that the lower state of the emission is not the ground state. No significant chemical interaction between the molecule and the rare gas is seen for any of the observed states.

16613. Mihalas, D., Kunasz, P. B., Hummer, D. G., **Solution of the comoving-frame equation of transfer in spherically symmetric flows. IV. Frequency-dependent source functions for scattering by atoms and electrons,** *Astrophys. J.* **210,** No. 2, 419-433 (Dec. 1, 1976).

Key words: early-type stars; electron scattering; spectral-line formation; stellar atmospheres.

A numerical method is presented of solving the radiative transfer equation in the comoving frame of a spherically symmetric expanding atmosphere in which both the line and the electron-scattering source function can depend on frequency (i.e., when there is partial frequency redistribution in the scattering process). This method is used to assess the adequacy of various assumptions regarding frequency redistribution in the comoving frame and to discuss the effects of electron scattering more accurately than previously possible. The methods developed here can be used in realistic model atmospheres to account for the (major) effects of electron scattering upon emergent flux profiles.

16614. Langhoff, P. W., Hernandez, A. J., **On the Brueckner and Goldstone forms of the linked-cluster theorem,** *Int. J. Quant. Chem. Symp.* **10,** 337-352 (1976).

Key words: diagrammatic perturbation theory; linked-cluster theorem; many-body theory.

Connections between the Brueckner and Goldstone forms of the linked-cluster theorem are clarified in an elementary fashion employing a finite many-body system of electrons interacting via two-body forces as an illustrative example. It is shown that the order-by-order cancellations of Brueckner unlinked terms in the many-body wave function and energy occur in the Goldstone development upon the additions of the different time orderings of Feynman-Goldstone diagrams having disconnected vacuum parts. The factoring of the vacuum amplitude from the wave function, upon which customary presentations of the theorem focus attention, is shown to be irrelevant to the cancellations of Brueckner unlinked terms, and has to do, rather, with the presence of secular and normalization terms in the time-dependent perturbation functions for an adiabatically-switched static perturbation. Similarly, the equivalence of the vacuum amplitude with the exponential of all connected vacuum diagrams, originally demonstrated by Feynman in the case of hole theory, is shown to be irrelevant to the cancellations of Brueckner unlinked terms in the energy, which occur in the Goldstone development upon the summations over all time orderings of disconnected vacuum diagrams. The distinction between Brueckner unlinked terms on the one hand, and secular and normalization terms on the other, is confused in customary presentations of the linked-cluster theorem by the use of exponential switching, following Gell-Mann and Low, and is clarified in the present development by considering the Friedrichs limit of ideal adiabatic switching.

16615. Zamir, E., Szöke, A., Osgood, R., **Fluorescence and dissociative energy transfer in high pressure Ar-HCN mixtures excited by relativistic electrons,** *J. Chem. Phys.* **65,** No. 11, 4885-4894 (Dec. 1, 1976).

Key words: energy transfer, electronic; fluorescence; molecular dissociation; relativistic electrons, excitation.

Studies of the radiation from Ar-HCN and Ar-H_2O mixtures, excited by relativistic electrons from a Febetron 706 electron gun, are presented. The energy deposited by the electrons channels rapidly into the Ar* and Ar_2* states; then by dissociative collisions with HCN it is transferred partly into the CN(B) state and partly into a reservoir state [most probably the CN(A) state] with near unit efficiency. Fluorescence emission from the electronic states $A(^2\Pi_i)$ and $B(^2\Sigma^+)$ of the CN radical, as well as the emission from the Ar_2* excimer state, were measured for an Ar pressure range of 750-9000 torr [15-180 psi(absolute)], and an HCN pressure range of 0.2-13 torr. The quenching rates of Ar* metastable and the Ar_2* excimer states, by collision with HCN molecules, were measured to be 6×10^{-10} and 1×10^{-9} cm^3 sec^{-1}, respectively. Our results suggest that population inversion can be achieved by collisional dissociation of simple molecules with excited rare gas atoms and excimers. Indeed the peak CN(B) population density was found to be 1.5×10^{15} cm^{-3}, which corresponds to an optical gain for the B-X transition of 0.4 cm^{-1} if the ground state is empty. A computer kinetic model is presented that explains the time dependence and intensity of the CN(B) emission. In Ar-H_2O mixtures the reaction rate for quenching of Ar_2* excimer by H_2O molecules is extremely high; however, the yield into the OH($A^2\Sigma^+$) is only 3 percent.

16616. Maxfield, B. W., Linzer, M., McConnaughey, W. B., Hulbert, J. K., **Design of permanent magnet electromagnetic acoustic-wave transducers (EMATs),** *Proc. 1976 IEEE Ultrasonics Symp., Annapolis, MD, Sept. 29-Oct. 1, 1976,* 4 pages (The Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: electromagnetic transducer; EMAT; transducer; ultrasonics.

Electromagnetic acoustic-wave transducers (EMATs) provide a means of generating and detecting shear and compressional acoustic waves of known amplitude in conductors by electromagnetic instead of mechanical coupling to the material under study. An EMAT consists of a coil to generate eddy currents in the conductor and a magnetic field to provide coupling between the eddy currents and the metal lattice. Most work to date has been on EMATs utilizing either large permanent magnets or electromagnets. Here we describe a simple but very practical model for a rare-earth cobalt permanent magnet EMAT. This model is analyzed in detail and compared with measurements of the performance of a compact (250 gram) EMAT.

16617. Wiederhorn, S. M., Fuller, E. R., Jr., Mandel, J., Evans, A. G., **An error analysis of failure prediction techniques derived from fracture mechanics,** *J. Am. Ceram. Soc.* **59,** No. 9-10, 403-411 (Sept.-Oct. 1976).

Key words: crack propagation; error analysis; failure prediction; failure prevention; fracture; statistics; strength.

Three principal methods of failure prediction for brittle materials are analyzed statistically. Each method depends on fracture mechanics for its predictive value; hence the variance of the failure time depends on the scatter in the fracture mechanics data and the scatter in the estimate of the initial size of the strength-limiting crack. The variance is used to calculate confidence limits for the prediction of failure for glass and SiC. Procedures for the collection and analysis of data are discussed and the implications of the analysis for lifetime prediction are evaluated.

16618. Brandt, M. A., Truhlar, D. G., Van-Catledge, F. A., **Electron scattering by nitrogen molecules: Theory and application to elastic scattering and rotational excitation at 30-75 eV,** *J. Chem. Phys.* **64,** No. 12, 4957-4967 (1976).

Key words: close coupling calculations; cross sections; differential cross sections; elastic scattering; electron scattering; momentum transfer; nitrogen molecules; rotational excitation; scattering theory.

An effective potential model applicable to electron scattering by small or large molecules, including rotational and vibrational motions, is developed for electron scattering by N_2. The INDO/1s method is used to calculate the static potential at a large number of distances and a simple model is used for the polarization potential. The rotational and vibrational matrix elements of these potentials are accurately calculated and the scattering is treated by a truncated close-coupling expansion. With no adjustable parameters, calculated electronically and vibrationally elastic scattering cross sections are in reasonable agreement with experiment for angles 40°-50° and less at energies 30-75 eV. The rotational excitation cross sections have never been measured for N_2 but are predicted to be large (as large as half the pure elastic cross sections when integrated over scattering angles and larger than the pure elastic differential cross sections at a range of large scattering angles at each energy).

16619. Kostkowski, H. J., **Current status and future plans for NBS radiometric source standards,** *Proc. AIAA/NASA/ASTM/IES Space Simulation Conf., Silver Spring, MD, Nov. 3-5, 1975,* Paper No. 66, pp. 799-805 (National Aeronautics and Space Administration, Washington, DC, 1976).

Key words: blackbodies; lamp standards; radiometry; remote sensing; solar monitoring; source standards.

The accuracy and long-term stability of currently available NBS radiometric source standards will be described. Current research efforts and expected results in this area will be outlined.

16620. Buehler, M. G., Sawyer, D. E., **Microelectronic test patterns for use in procuring reliable, custom integrated circuit chips,** (Proc. Government Microcircuit Applications Conf., Orlando, FL, Nov. 9-11, 1976), Paper in *Government Microcircuit Applications Conference Digest,* **VI,** 62-65 (Nov. 1976).

Key words: circuit procurement; component screening; custom circuits; LSI; microelectronics; parameter control; process uniformity; random faults; reliability; test patterns; TTL; vendor qualification.

The current procurement methods for obtaining custom integrated circuits for high-reliability applications are expensive, less than fully effective, and cause long delays in delivery.

An approach being developed at the National Bureau of Standards focuses on a process validation wafer (PVW) concept which is intended to evaluate process and circuit parameter uniformity, and to measure the occurrence of random faults such as pin holes, multicontact resistance, and emitter-collector pipes. The PVW is an entire wafer of test structures and is intended to be fabricated along with product wafers on a periodic basis. As a process characterization tool, it can be used to qualify vendors and can serve as a circuit acceptance criterion. This concept has the potential of greatly reducing the user-imposed requirements that now accompany a high-reliability component purchase.

16621. Smith, W. W., Gilbert, D. A., Peterson, C. W., **Vacuum ultraviolet emission spectra from keV energy rare gas ion-atom collisions,** (Proc. 4th Int. Conf. on Beam Foil Spectroscopy, Gatlinburg, TN, Sept. 15-19, 1975), Paper in *Beam-Foil Spectroscopy,* I. A. Sellin and D. J. Pegg, Eds., **2,** 695-704 (Plenum Press, New York, NY, 1976).

Key words: electron-promotion model; ion-atom collisions; solar corona; vacuum ultraviolet emission spectra; vacuum ultraviolet lasers.

Emission spectra have been observed under single-collision conditions in the 500-1100 Å wavelength range and 10-30 keV ion beam energy range for collisions of (He^+, Ne^+, Ar^+) + Ar, as well as Ar^+ + Ne, Ar^+ + He and Ne^+ + Ne. The Ar I and Ar II spectra observed with an argon gas target are similar to those observed previously with He^+ + Ar by de Heer and by Isler, except that with Ar^+ + Ar excitation both the Ar I 4s resonance lines and the 3d-3p transitions in the Ar I spectrum are relatively more prominent than with the other projectiles. A striking difference is found between the strong excitation of the 920 and 932 Å lines of Ar II by a Ne^+ beam on Ar (cross section $\sim 7 \times 10^{-17}$ cm^2 at 30 keV) compared with weak excitation of these lines using Ar^+ + Ne in the same energy range. With Ne^+ + Ne, the most prominent lines observed were the 3s and 4s resonance lines of Ne I. Approximate absolute emission cross sections are given for a number of lines. The results are discussed in terms of the electron-promotion (molecular orbital) model of ion-atom collisions. This work may have applications to excitation processes in the solar corona and in vacuum uv lasers.

16622. Wacker, P. F., **Quantifying hazardous microwave fields: Analysis,** *Proc. Symp. on the Biological Effects and Health Implications of Microwave Radiation, Richmond, VA, Sept. 17-19, 1969, BRH/DBE 70-2,* 197-203 (U.S. Department of Health, Education, and Welfare, Rockville, MD, June 1970).

Key words: hazardous microwave fields.

The existing standards for microwave radiation hazards are based upon far-field concepts which may have little or even no validity in near fields. However, hazards occur largely in near fields, and even many dosimetry experiments are carried out in near fields. Because of the great complexity possible in a near field, a probe should, in principle, simulate the individual who might be subject to the possible hazard; however, such a probe is not feasible. Electric energy density provides a reasonable index of a large class of microwave radiation hazards and is simpler to measure in a near field than is energy flow. Analytical aspects of near field measurements are discussed in general, and design of a possible probe described in detail.

16623. Freund, S. M., Sweger, D. M., Travis, J. C., **Quantitative detection of nitrogen dioxide in nitrogen using laser magnetic resonance at 1616 cm^{-1},** *Anal. Chem.* **48,** No. 13, 1944-1946 (Nov. 1976).

Key words: infrared detection; laser magnetic resonance; modulated absorption; nitrogen dioxide; NO_x detection; quantitative detection.

The selective, quantitative detection of nitrogen dioxide in part-per-million concentrations in nitrogen using magnetic field modulation of the molecular absorption of 1616 cm^{-1} carbon monoxide laser radiation is reported. A magnetic field of less than 500 gauss is sufficient to shift the infrared transition of interest into coincidence with the laser. The Zeeman-modulated absorption of the laser light is synchronously detected, and is found to vary linearly with NO_2 concentration over the two orders of magnitude investigated. The synchronous detection scheme discriminates against nonparamagnetic species, such as water and ethylene, which could interfere with direct absorption measurements.

16624. Conti, D. M., **A method for estimating service bureau processing charges,** *Proc. 7th Int. Conf. of the Computer Measurement Group, Inc., Atlanta, GA, Nov. 16-19, 1976,* pp. 34-60 (Computer Measurement Group, Camp Springs, MD, Nov. 1976).

Key words: benchmarking; charging algorithms; service bureaus; synthetic benchmarking; workload characterization.

This paper describes the development of a new synthetic benchmark technique for estimating batch processing charges at service bureau sites. This technique was used to estimate the cost of processing a large batch workload at a number of service bureaus within the same vendor line. The method was found to be low-cost, yet reasonably accurate for a certain class of service bureau charging algorithms. Refinements of this method are suggested which will extend its applicability to other algorithms. The procedures used to create and run the benchmark, together with the projection of total workload costs are described.

16625. McMichael, J. M., Mease, N. E., **On the application of tension to compliant membranes,** *AIAA J. Tech. Notes* **14,** No. 10, 1490-1492 (Oct. 1976).

Key words: air impedance; compliant surface; drag reduction; membranes; tension; vibrating membranes.

In connection with a study of the feasibility of achieving drag reduction by the use of compliant surfaces in turbulent boundary-layers, a method of applying tension to rectangular compliant membranes by the use of suction in chambers adjacent to the free membrane area has been developed. A description of the method is presented along with data evaluating the method. Measurements of the impedance effect of the ambient air on the frequencies of the normal modes of vibration are also presented.

16626. Penn, R. W., Fong, J. T., Kearsley, E. A., **Experience in data acquisition and reduction for a biaxial mechanical testing program,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 613, Use of Computers in the Fatigue Laboratory,* pp. 78-93 (American Society for Testing and Materials, Philadelphia, PA, 1976).

Key words: biaxial; fatigue; fracture; laboratory automation; mechanical testing; plasticity; polyvinyl chloride; servo-hydraulic system; viscoelasticity; yield point.

The inadequacy of uniaxial mechanical testing data as a basis for predicting multiaxial deformation and fracture is well known. For optimal biaxial tests, computer control of simultaneous variation of loadings using hydraulic power under closed loop servocontrol is essential. Computer assistance in real time data reduction from a biaxial mechanical test is economical. Physical features of computer hardware, software, and a hydraulic biaxial system are described along with sample results illustrating cross effects in fatigue and yield surface calculations. Significance of the graphical output based on thin tube specimens of 1-in. (2.54-cm) nominal diameter, schedule 80, commercial grade polyvinyl chloride pipes, and the limitations of the present system are discussed.

16627. Truhlar, D. G., Merrick, J. A., Duff, J. W., **Comparison of trajectory calculations, transition state theory, quantum mechanical reaction probabilities, and rate constants for the collinear reaction $H + Cl_2 \rightarrow HCl + Cl$,** *J. Am. Chem. Soc.* **98,** 22, 6771-6783 (Oct. 27, 1976).

Key words: chemical reactions; chlorine molecules; classical scattering matrix theory; collision theory; cross sections; hydrogen atoms; rate coefficients; scattering theory; trajectories; transition-state theory.

Quantum mechanical rate constants are computed for the collinear reaction $H + Cl_2 \rightarrow HCl + Cl$ using the reaction probabilities of Baer. For comparison we also computed reaction probabilities and rate constants for this reaction using (a) the quasiclassical trajectory method, (b) the reverse quasiclassical trajectory method, (c) the classical **S** matrix theory (using real-valued trajectories only), and (d) transition-state theory assuming separability of the reaction coordinate at the transition state. Comparisons are made not only for total reaction probability and total rate constant but also in general for state-to-state reaction probabilities and state-to-state rate constants. The quasiclassical trajectory method is generally accurate except in the threshold regions for various state-to-state processes. It is more accurate for total reaction probabilities and total rate constants than for state-to-state reaction probabilities and rate constants. The quasiclassical trajectory calculations of total rate constants for reaction in a given initial vibrational state agree with the quantum calculations within 29 percent for the 300-1000 K temperature range but the state-to-state rate constants may be in error by a factor of 2 or more even for processes which are classically allowed in the sense of classical **S** matrix theory. Classical **S** matrix theory does not always provide a more accurate way to extract state-to-state reaction probabilities from these trajectories. Transition state theory (which yields average reaction probabilities and total rate constants for a thermal distribution of initial states but does not yield state-to-state results) is fairly accurate for this reaction even with the assumption that the reaction coordinate is separable.

16628. Parris, G. E., Brinckman, F. E., **Reactions which relate to environmental mobility of arsenic and antimony. II. Oxidation of trimethylarsine and trimethylstibine,** *Environ. Sci. Technol.* **10,** No. 12, 1128-1134 (Nov. 1976).

Key words: antimony; antimony oxide; arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; trimethylarsine; trimethylstibine.

Oxidation of trimethylarsine and trimethylstibine by atmospheric oxygen and other reagents is examined, and semiquantitative rate constants are calculated. In methanol solution the rate constant for reaction of dissolved oxygen with trimethylstibine is greater than 10^{-2} M^{-1} s^{-1}, whereas for the oxidation of trimethylarsine, the rate constant is less than 10^{-2} M^{-1} s^{-1}. In the gas phase the rate constants are estimated as 10^{9} and 10^{-6} M^{-1} s^{-1} for reaction of trimethylstibine and trimethylarsine, respectively, with oxygen. A scheme based on PMR evidence for reactive intermediates is suggested to account for the products of oxidation, $(CH_3)_3EO$ and $(CH_3)_2EO_2H$, of these compounds $(CH_3)_3E$, E = Sb, As. From these results, even if biological methylation of antimony occurs in nature analogous to that of arsenic, the rapidity with which $(CH_3)_3Sb$ is oxidized would probably prevent hazardous concentrations from building up in aerated surroundings.

16629. Voth, R. O., Hord, J., **Economics of cryocables,** *Int. J. Hydrogen Energy* **1,** 271-289 (1976).

Key words: a.c. power; cryoresistive; energy transmission economics; helium; hydrogen energy; liquid hydrogen; liquid nitrogen; power transmission cables; safety; slush hydrogen; superconducting.

This paper examines the technical and economic feasibilities of: (1) using cryogenic hydrogen to cool a.c. cryoresistive or a.c. superconducting power transmission cables and, (2) delivering liquid hydrogen concurrently with cryoresistive or superconducting electrical power through a common cable. Cryogenic hydrogen coolant options considered are subcooled liquid and slush. Cryogenic nitrogen and helium coolants are also considered for cryoresistive and superconducting cables, respectively, to provide reference data for comparison with our H_2-coolant calculations. Thermodynamic analyses are performed to optimize the coolant flow rate and refrigerator spacing for each specific coolant, coolant fluid state, cable design, cable insulation quality and energy delivery option. The use of hydrogen as a coolant in electrical cables is discussed from a safety viewpoint.

Helium-cooled and hydrogen-cooled superconducting power transmission lines are shown to be economically competitive and offer lower unit-transmission costs than conventional underground power lines. The hybrid hydrogen-superconducting cable concurrently transmits liquid hydrogen and electricity at the lowest unit cost of all cryocable energy systems examined. Hydrogen-cooled power lines and hybrid hydrogen-electric energy cables appear to be technically and economically feasible; however, they do not currently provide sufficient economic incentive to warrant the increased hazard of operation.

16630. Kusuda, T., **Procedure employed by the ASHRAE Task Group for the determination of heating and cooling loads for building energy analysis,** *ASHRAE Trans.* **82,** Pt. 1, 305-322 (1976).

Key words: algorithm; ASHRAE; buildings; computer; energy calculation; heat transfer; heating and cooling loads; response factor.

Most up-to-date thermal load calculation methodology recommended by the ASHRAE Task Group on Energy Requirements is based upon an exact solution of the heat exchange equations among the room surfaces, room furnishings, lighting fixtures, equipment, occupants, and room air. Simplified calculation procedures are possible by the use of transfer functions or by a linear regression equation which could be derived from the rigorous calculation. Although the simplified solutions are entirely adequate for the energy calculation of conventional residential buildings or buildings which do not have the multiplicity of zones and complex air side systems, an exact and rigorous calculation method has a few advantages, some of which were discussed in the main text.

The advantages or the uniqueness of exact calculation procedures are to assist engineers who are willing to explore various energy conservation features or innovative building designs such as the use of interior mass of the building for the storage of off-peak cooling,

nighttime setback of the thermostat, flushing of the building with cool night air and the critical matching of the equipment with the indoor comfort requirements.

Although the exact method may appear formidable from the standpoint of algorithmic complexity as compared to the simplified steady state calculation, the use of computer programs which employ such a method will become much easier as the programming technique improves and as more computers are made larger, faster and more readily accessible in the near future.

Only the comprehensive load calculation methodology prepared by the ASHRAE Task Group on Energy Requirements enables the engineer to take advantage of the rapidly growing computer technology to meet the challenges of innovative building design.

16631. Diller, D. E., **Thermophysical properties data research on compressed and liquefied gases at the NBS Cryogenics Division,** (Proc. Cryogenic Engineering Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975), Paper M-7 in *Advances in Cryogenic Engineering* **21**, 522-531 (Plenum Press, New York, NY, 1976).

Key words: density; dielectric constant; electromagnetic properties; equation of state; ethane; hydrocarbon; liquefied natural gas; measurements; methane; mixtures; thermodynamic.

This report summarizes important NBS contributions to accurate thermophysical properties data from compressed and liquefied gases (helium, hydrogen, nitrogen, oxygen, fluorine and argon), and discusses research on liquefied hydrocarbon gases (methane, ethane, ethylene, etc.) and their mixtures. Representative results of research on the thermophysical properties of methane and mixtures containing methane are presented. Additional contributions expected through 1977 are summarized.

16632. Fickett, F. R., **Magnetic and electrical properties of internally oxidized CuFe alloys,** (Proc. Joint MMM-Intermag Conf., Pittsburgh, PA, June 15-18, 1976), *AIP Conf. Proc. No. 34, Magnetism and Magnetic Materials—1976*, J. J. Becker and G. H. Lander, Eds., pp. 25-26 (American Institute of Physics, New York, NY, 1976).

Key words: alloy; copper; cryogenic; iron; oxide; resistivity; remanance; susceptibility.

A series of CuFe alloys containing 1-100 at. ppm Fe has been internally oxidized. In nearly all cases the specimens become ferromagnetic. We have measured the remanent moment and low field susceptibility at room temperature, and the electrical resistivity at 273 K and 4 K. These data combined with Curie temperature measurements and scanning electron microscopy indicate the presence of very small single domain grains of copper ferrite within the copper matrix. The annealing process appears to be capable of sweeping most of the iron impurities from the matrix in spite of their very low concentrations.

16633. Daney, D. E., **Low-temperature losses in supercritical helium refrigerators,** (Proc. Cryogenic Engineering Conf., Kingston, Ontario, Canada, July 22-25, 1975), Paper E-4 in *Advances in Cryogenic Engineering* **21**, 205-212 (Plenum Press, New York, NY, 1976).

Key words: Brayton cycle; cryogenic refrigeration; refrigeration; superconducting transmission lines.

A comparison is made of the efficiencies of the low temperature portion of three alternative schemes of supercritical helium refrigeration for higher temperature superconducting transmission lines. The range of transmission line operating conditions considered is load pressures from 3 to 20 atm and load temperatures from 8 to 14 K. The analysis indicates that no single scheme demonstrates a marked superiority at higher pressures, and that the use of a low temperature pump does not greatly reduce the system efficiency at higher pressures.

16634. Arvidson, J. M., Hord, J., Mann, D. B., **Dispersion of hydrogen or methane fuels released into an automobile interior,** (Proc. Cryogenic Engineering Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975), Paper J-3 in *Advances in Cryogenic Engineering* **21**, 387-398 (Plenum Press, New York, NY, 1976).

Key words: automobile; detection; dispersion; explosion; fire; hydrogen; leakage; methane; safety; vents.

Gasoline-powered automobiles are being converted to operate on gaseous fuels such as hydrogen (H_2) or methane (CH_4). The fuel is often stored as a cryogenic liquid (H_2 at 20 K and CH_4 at 112 K) in dewar-like vessels located in the trunk of the car. Cryogenic storage provides four to five times greater vehicle range than gas storage in high pressure cylinders of comparable volume. Potential leakage of these gaseous fuels into the passenger compartment of the vehicle constitutes a safety threat. Definitive experiments were performed to identify the explosion hazards and establish venting criteria and general safe-guards for H_2 or CH_4 fueled passenger vehicles. Initial tests were conducted using methane at three inlet temperatures (300, 200, and 121 K) and it was determined that the gas dispersion patterns were not temperature dependent. Appropriately designed ventilation systems can significantly reduce the safety hazards associated with accumulated combustible gases. Vents are recommended for all autos converted to burn H_2 or CH_4 and may possibly be eliminated in new cars that are designed for gaseous fuel operation. Combustible gas warning systems are recommended, at least in the interim, for all (converted and new-design) gaseous fueled vehicles. H_2 and CH_4 gases appear equally safe as vehicular fuels if used in properly designed vehicles.

16635. Ledbetter, H. M., Moment, R. L., **Elastic properties of face-centered-cubic plutonium,** *Acta Met.* **24**, No. 10, 891-899 (Oct. 1976).

Key words: bulk modulus; compressibility; Debye temperature; elastic constants; plutonium; plutonium alloy; Poisson ratio; shear modulus; sound velocity; Young modulus.

The three principal elastic constants, C_{ij}, of f.c.c. plutonium were determined by measuring the ultrasonic wave velocities along a near−⟨110⟩ direction in a single crystal. The elastic anisotropy is twice that known for any other f.c.c. metal. The elastic-anisotropy problem is considered using a general two-body central-force interatomic potential. Based on the C_{ij}, polar plots of the wave velocities and Young's modulus were determined. The C_{ij} were "averaged" to obtain quasi-isotropic elastic constants, which are compared with existing polycrystalline elastic data. The elastic Debye temperature was computed by numerically integrating the Christoffel equations.

16636. Clark, A. F., **Stress effects in superconductors,** *Cryogenics* **16**, No. 10, 632-633 (Oct. 1976).

Key words: critical current; mechanical properties; stress effects; superconductors; symposium.

A one day symposium on stress effects in superconductors is summarized.

16637. Parrish, W. R., Hiza, M. J., **On the consistency of liquid-vapor equilibria data for binary mixtures on methane with the light paraffin hydrocarbons,** (Proc. Cryogenic Engineering Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975), Paper M-2 in *Advances in Cryogenic Engineering* **21**, 485-492 (Plenum Press, New York, NY, 1976).

Key words: critical loci; excess Gibbs' energies; Henry's constants; liquid-vapor equilibria; methane-light hydrocarbon binary mixtures.

Published experimental liquid-vapor equilibria data for the binary systems of methane with ethane, propane, isobutane, and normal bu-

tane have been compiled and evaluated for internal and mutual consistency. Equimolar excess Gibbs energies and infinite dilution Henry's constants are obtained by a method which uses only P − x data. The derived equimolar excess Gibbs energies are compared with those calculated from a modified hard-sphere model for the equimolar mixtures. Critical loci (P_c, T_c, x_c) are also examined where available. Discrepancies in the data are enumerated which suggest the desirability of more precise and accurate measurements.

16638. Siegwarth, J. D., Holste, J. C., Morrow, A. J., **Polarization and dielectric constant of potassium tantalate,** *J. Appl. Phys.* **47,** No. 11, 4791-4793 (Nov. 1976).

Key words: dielectric constant; dielectric relaxation; electret; polarization; potassium tantalate.

The polarization of $KTaO_3$ single crystal and some $KTaO_3$ ceramic specimens has been measured using a dc technique. A remanent polarization was found as well as hysteresis in the polarization as a function of field. Peaks in the ac dielectric constant were also observed. These dielectric properties are attributed to dielectric relaxation effects and the existence of an electret state.

16639. Siegwarth, J. D., Morrow, A. J., **Low-temperature polarization in impure $SrTiO_3$ ceramics,** *J. Appl. Phys.* **47,** No. 11, 4784-4790 (Nov. 1976).

Key words: dielectric relaxation; electret state; impurity; ordering transition; polarization; remanent; strontium titanate.

Measurements of the temperature dependence of the dielectric constant and polarization in a constant field have been made on nominally pure $SrTiO_3$ ceramics and $SrTiO_3$ ceramics containing vanadium and niobium impurities. The peaks in the dielectric constant and the remanent polarization observed are apparently not due to a ferroelectric or antiferroelectric transition but rather to the presence of a thermoelectret state existing for permanent dipoles in the materials. It is suggested that the permanent dipoles have an origin similar to the impurity-vacancy dipoles found in alkali halides.

16640. Fowlkes, C. W., Tobler, R. L., **Fracture testing and results for a Ti-6Al-4V alloy at liquid helium temperature,** *Eng. Fract. Mech.* **8, 487-500 (1976).**

Key words: crack propagation; cryostats; fracture tests; low temperature tests; mechanical tests; titanium alloys.

This paper discusses fracture toughness and fatigue crack growth testing at liquid helium temperature, 4 K (− 452 °F). The design and performance of a fracture testing cryostat and associated instrumentation are described. Fracture toughness and fatigue crack growth data for Ti-6Al-4V from room temperature to 4 K are presented.

16641. Jespersen, J. L., **Topside spread-F and satellite radio scintillations,** (Proc. 10th Annual Symp. of the Ionospheric Research Committee of the Avionics Panel of AGARD/NATO, Rome, Italy, Sept. 21-25, 1965), Chapter 3-9 in *AGARD Conference Proceedings 3, Propagation Factors in Space Communications,* pp. 203-207 (Technivision, Maidenhead, England, 1967).

Key words: absorption; high latitude; ionosphere; ionospheric scattering; irregularity; satellite; scintillation; spread-F; topside.

Over the last decade many workers have studied the relation between spread-*F*, detected by ground-based ionospheric sounders, and the scintillation of a radio signal either from a radio star or from an artificial earth satellite. In this paper the relation between scintillations and spread-*F* detected by the topside sounder satellite, *Alouette I*, near College, Alaska, is studied. The scintillations are correlated with small-scale irregularities in the vicinity of the satellite. This supports the view that high-latitude irregularities extend from near h_{max} to as high as 1000 km. Simultaneous topside and bottomside soundings of the ionosphere, taken together with the scintillation observations, suggest that on occasion the ionospheric disturbance, associated with the irregularities, extends below h_{max} into the *D* region.

16642. Smith, R. V., **Fluid dynamics,** Chapter 5 in *Cryogenic Fundamentals,* pp. 237-310 (Academic Press, New York, NY, 1971).

Key words: compressibility flow; cryogenics; fluid dynamics; pressure drop; superfluid helium; two phase flow.

This chapter reviews the field of fluid dynamics with special emphasis on the behavior of cryogenic fluids.

16643. Peterson, R. L., **The magnetophonon effect,** Chapter 4 in *Semiconductors and Semimetals* **10,** *Transport Phenomena,* R. K. Willardson and A. C. Beer, Eds., pp. 221-289 (Academic Press, New York, NY, 1975).

Key words: magnetophonon effect; semiconductors; transport theory.

This article is a comprehensive review of the magnetophonon effect. All theoretical and experimental articles published to date are referenced and discussed. An attempt is made to point out the weaknesses and unique contributions of the various publications. A broad overview, and a discussion of uncompleted work and likely areas for new efforts, are also given so that both the casual reader and the serious researcher will be benefitted.

16644. Jespersen, J. L., Gatterer, L. E., Hanson, D. W., Hamilton, W. F., **Artificial satellites as a means of time dissemination,** *Proc. Int. Conf. on Space and Communications, Paris, France, Mar. 29-Apr. 2, 1971, Paper 16 D,* pp. 426-433 (L'Espace et la Communication Observation: Metrologie, Geodesia Localisation, Paris, France 1971).

Key words: communication satellite; communication system; hf time dissemination services; navigation system; satellite time and frequency dissemination services.

Satellite time and frequency dissemination systems offer certain advantages over conventional HF broadcast services. Some of the important deficiencies of HF broadcasts are discussed together with the corresponding advantages of satellite systems. Experimental results obtained at NBS using UHF/VHF satellite transponders are reviewed. Work performed by other experimenters at higher frequencies is described.

The relationship of disseminated time and frequency to the design and operation of navigation and communication systems is described. There are significant advantages to relating the time and frequency information disseminated incidental to navigation and communication system operation to external standards.

16645. Haynes, W. M., Hiza, M. J., Frederick, N. V., **Magnetic suspension densimeter for measurements on fluids of cryogenic interest,** *Rev. Sci. Instrum* **47,** No. 10, 1237-1250 (Oct. 1976).

Key words: apparatus; density; experimental; magnetic suspension; methane; nitrogen; saturated liquid; tables.

An apparatus incorporating a magnetic suspension technique has been developed for density measurements on liquids and liquid mixtures, particularly at saturation, at temperatures between 90 and 300 K and at pressures to 5 MPa (approximately 50 atm). The feasibility of adapting this method, previously used at room temperature, for low temperature use had been demonstrated in an earlier study with a density measurement on saturated liquid nitrogen near its normal boiling point. The present apparatus, which is significantly improved, and in most respects different from the earlier model, is described in detail. It includes a cryostat for continuous wide-range temperature control, a windowed equilibrium cell particularly suited for studies of liquid mixtures, and a new electronic servocircuit with a linear dif-

ferential transformer for position control of the magnetic buoy. Extensive tests and density measurements have been carried out to evaluate the performance of this apparatus. Densities of saturated liquid nitrogen between 95 and 120 K and saturated liquid methane between 105 and 160 K are reported. The estimated standard deviation of a single density measurement is less than 0.02 percent. The total systematic error in the measurement process from known sources is approximately 0.05 percent. The total uncertainty of a single density measurement, which is taken as three times the standard deviation plus the systematic error, is approximately 0.1 percent. Comprehensive comparisons of the present results with previous experimental data are presented.

16646. Haynes, W. M., Hiza, M. J., **Orthobaric liquid densities of normal butane from 135 to 300 K as determined with a magnetic suspension densimeter,** (Proc. Cryogenic Engineering, Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975), Paper M-6 in *Advances in Cryogenic Engineering* **21,** 516-521 (Plenum Press, New York, NY, 1976).

Key words: density; experimental; magnetic suspension densimeter; normal butane; saturated liquid; table.

A magnetic suspension densimeter, developed for absolute density measurements of the principal components of liquefied natural gas and their mixtures, has been used to determine the orthobaric (saturated) liquid densities of normal butane from 135 to 300 K. These measurements provide the first set of density data for liquid-*n*-butane that spans the range of temperatures from near ambient to just above the triple point, 134.8 K. These new data have been fitted to a simple analytical expression to provide a convenient and precise interpolation method. This equation has also been used to calculate densities for the subcooled liquid region at temperatures normally associated with liquefied natural gas. The precision and repeatability of measurement is within two parts in 10,000 or better. The absolute error in the densities is estimated to be less than $\pm$ 0.1 percent.

16647. Warnar, R. B. J., **Letter to Editor on "Trends in Computer Hardware Technology," by David A. Hodges,** *Computer Design* **15,** No. 12, 14 (Dec. 1976).

Key words: cells; charge-coupled device (CCD); chevron; garnet; large-scale-integration (LSI); line width; lithography; magnetic bubble device (MB); memory storage density; N-channel metal-oxide-semiconductor (N-MOS); random-access-memory (RAM); silicon.

The December 1976 COMPUTER DESIGN magazine includes a "Letter to the Editor" from the Information Technology Division, ICST, regarding an article "Trends in Computer Hardware Technology" (COMPUTER DESIGN, February 1976, pp. 77-85). Information included in the letter was derived from the soon-to-be-published Special Publications "Foreign and Domestic Accomplishments in Magnetic Bubble Device Technology" and "Foreign and Domestic Accomplishments in Charge-Transfer Device Technology." Information included in the letter clarified certain specific statements of the February article in the areas of bit-density and cost of charge-coupled devices (CCD's) and magnetic bubble memories (MB's). Specific differences in fabrication techniques between conventional LSI solid-state circuitry and CCD/MB fabrication techniques are highlighted.

16648. McLaughlin, W. L., Humphreys, J. C., Chappell, S. E., Olejnik, T. A., Fox, C. E., **Physical measurements for quality control in industrial radiation sterilization,** (Proc. Int. Conf. on Physics in Industry, Dublin, Ireland, Mar. 8-13, 1976), Paper in *Physics in Industry*, E. O'Mongain and C. P. O'Toole, Eds., pp. 567-573 (Pergamon Press, Oxford, England, 1976).

Key words: dosimetry; electron beams; gamma rays; physical measurements; quality control; radiation measurement; radiation processing; radiation sterilization; radiochromic dyes; Red Perspex; sterility control.

The use of ionizing radiation has brought about a growing industry for the sterilization of disposable surgical equipment, medical supplies, and containers for biological specimens. For many products, irradiation has become an alternative to autoclaving or gas treatment by ethylene oxide. Over fifteen years of experience with industrial sterilization by cobalt-60 gamma radiation have shown that radiation methods provide a clear advantage over gas sterilization, in that sterilization can be performed on nonpermeable sealed packages. Moreover, regulatory agencies, such as the Food and Drug Administration in the U.S.A., are reappraising the requirements for sterility assurance. For products released to the public, consideration is now being given to the use of physical dosimetry, i.e., the measurement of radiation dose by physical methods. This is based on a knowledge of the microbial burden of the product before sterilization and on the probability of killing microorganisms by a given radiation dose. Because physical dosimetry is easier to control and less complicated than biological tests, it may be considered in the future the basis for quality assurance of the sterilized product. Some of the problems associated with standardized measurement techniques in radiation sterilization include the choice of dosimetry and its calibration, as well as methods and procedures used to minimize errors due to variations in radiation flux density, source geometry with respect to the product, and environmental factors.

16649. Hall, J. L., Lee, S. A., **Control techniques for cw dye lasers,** *Proc. Conf. on Tuneable Lasers and Their Applications, Leon, Norway, June 1976,* pp. 361-366 (Springer-Verlag, Berlin, Germany, 1976).

Key words: cw dye laser; frequency control; laser wavelength determination; scanning interferometer.

Stabilized cw dye lasers are potentially a most useful spectroscopic took but they bring a troublesome technology. We list the major problems specific to these lasers. We present a stabilized dye laser design which addresses these problems successfully to produce a useful widely tuneable laser with 50 kHz spectral width and exceptional high single mode power covers 10 K efficiency (12%). An automatic interferometer system is described which gives realtime numerical laser wavelength readout of sub-Doppler absolute accuracy.

16650. Zelkowitz, M. V., **Automatic program analysis and evaluation,** *Proc. 2nd Int. Conf. on Software Engineering, San Francisco, CA, Oct. 13-15, 1976,* pp. 158-163 (IEEE Computer Society, Long Beach, CA, Oct. 1976).

Key words: dynamic analysis; errors; evaluation; program complexity; program measurement static.

There is currently considerable interest in the computing community in the evaluation of computer programming. However, in order to objectively evaluate such concepts, it is necessary to undertake a thorough evaluation of the programming process itself. Most previous studies of this type have analyzed, by hand usually, a few instances of programs. This has led to some general conjectures; however, the amount of information that must be processed precludes any large scale analysis. In order to avoid this problem, an automatic data collection facility has been implemented as part of a PL/1 compiler at the University of Maryland. This system automatically collects information on each program that has been compiled—at almost no additional cost to the user of the compiler. This paper will describe the system and will evaluate some of the characteristics of some of the 25,000 programs that have been run since July, 1975.

16651. Crawford, M. L., Smart, G. R., **New coaxial thermistor mounts for use as precision transfer standards,** *Proc. Instrument Society of America Conf., Philadelphia, PA, Oct. 26-29, 1970,* No. 708-70, 1-6 (Instrument Society of America, Pittsburgh, PA, 1970).

Key words: coaxial thermistor mounts; precision transfer standards.

Improved thermistor mounts have been designed and constructed for use as precision low power transfer standards. Characteristics of these mounts which represent improvements over typical commercially available thermistor mounts are as follows: 1) Input VSWR $\leq$ 1.03 as compared to typical VSWR $\geq$ 1.1; 2) Provision for checking thermistor pair match (for similar characteristics), when dc bias is applied; 3) Use of precision 14 mm input connectors; 4) Extended frequency range from 1 MHz to 4.0 GHz and at specified frequencies from 4 to 8 GHz.

The paper describes the thermistor mount design and includes a mathematical analysis of an approximation to their equivalent circuit. Design equations and experimental results are given for the mounts along with a brief analysis of the errors.

16652. Mandel, J., **Statistical methods in analytical chemistry,** Chapter in *Treatise on Analytical Chemistry*, I. M. Kolthoff and P. M. Elving, Eds., Part III, Section C, **3,** 79-125 (John Wiley and Sons, New York, NY, 1976).

Key words: analytical chemistry; data analysis; design of experiments; statistics.

This chapter is an introduction, written mainly for the analytical chemist, to the use of statistics in designing experiments and analyzing data. Subjects covered include basic statistical concepts, precision and accuracy, interlaboratory comparisons and the Youden plot, calibration experiments, factorial experiments, analysis of structure, block experiments, comparison of test methods, control charts, confidence statements and propagation of errors. All subjects are illustrated in terms of data taken from analytical chemistry.

16653. Unassigned.

16654. Wyly, R. S., Galowin, L. S., **An approach to performance evaluation for water supply and drainage for buildings,** *Proc. CIB Commission W62 Symp., 1975, Drainage and Water Supply for Buildings, University of Glasgow, Glasgow, Scotland, Sept. 30-Oct. 1, 1975*, pp. 12/1-12/31 (1975).

Key words: acceptance protocol; performance approach; performance-based plumbing standard; performance statement; plumbing performance criteria; plumbing performance evaluation; plumbing performance.

The performance concept is reviewed as it relates to water supply and drainage for buildings.

An approach is described that is being utilized in connection with the development of a performance standard for plumbing as a complement to an updated specification-type (model) code of practice (National Plumbing Code) under the procedures of the American National Standards Institute.

The recommendation is made that the work in connection with the National Plumbing Code program include first a comprehensive review of existing information to identify existing performance statements, both those actually stated and those merely implied. Several examples are developed illustrating this concept.

It is concluded that the needs in further development and implementation of the performance approach include education, acceptance protocol and new research. The new research would be needed to establish definitive performance criteria, reproducible test procedures or predictive models, and systematic inspection procedures. During the period of transition to performance evaluation methodology, continued reliance will need to be placed on specification-oriented acceptance protocol, expert judgment and experience.

16655. Radebaugh, R., **He^3, He^4 refrigeration,** *Cryogenics* **11,** No. 1, 63 (Feb. 1971).

Key words: demagnetization; dilution refrigerator; helium 3; helium 4; liquid helium; mixtures; refrigeration.

A report of papers presented at the September 11, 1970 afternoon session of the IIP Commission I meeting is given. These papers are on the subjects of dilution and He^3 refrigerators.

16656. Sprowls, D. O., Summerson, T. J., Ugiansky, G. M., Epstein, S. G., Craig, H. L., Jr., **Evaluation of a proposed standard method of testing for susceptibility to stress-corrosion cracking of high-strength 7XXX series aluminum alloy products,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 610, Stress Corrosion—New Approaches*, pp. 3-31 (American Society for Testing and Materials, Philadelphia, PA, Nov. 1976).

Key words: Aluminum Association; ASTM; industrial atmosphere; round robin tests; seacoast atmosphere; standard; stress-corrosion; 3.5 percent NaCl; 7XXX aluminum alloys.

A task group sponsored jointly by The Aluminum Association and the ASTM has recommended a standard method of test for susceptibility to stress-corrosion cracking (SCC) of 7XXX aluminum alloy products (ASTM G 47-76). The proposed standard is a comprehensive method that specifies the corrosive environment and period of exposure, type of test specimen and method of loading, procedures for sampling various manufactured product forms, and guidelines for interpretation of test results. Final selection of test procedures was based on round robin tests performed in nine different laboratories and 3-year exposures to the atmosphere in both seacoast and inland industrial locations. A summary of test results is given to illustrate how the relative performance of three different tempers of 7075 alloy plate can be influenced by the choice of a test specimen, differences in the outdoor atmosphere, and interlaboratory variations in performing the standard 3.5 percent sodium chloride alternate immersion test.

16657. Ritter, J. J., Freund, S. M., **CO_2 transverse excitation laser induced photochemical enrichment of carbon isotopes,** *J. Chem. Soc. Chem. Commun.*, No. 20, 811-813 (Oct. 20, 1976).

Key words: carbon isotopes; carbonyl fluoride; CO_2 laser photolysis; difluorocarbene; difluorodichloromethane; isotope ratio; nitric oxide; oxygen; tetrafluoroethylene; transverse excitation laser; 2-methyl propene.

CO_2 transverse excitation laser photolysis of mixtures of Cl_2CF_2 with O_2, NO, and $Me_2C=CH_2$ is isotopically selective for carbon and experimental evidence indicates that the reaction may involve a laser produced difluorocarbene intermediate.

16658. Kessler, K. G., **The optics program in the Optical Physics Division at NBS,** *Opt. Eng.* **12,** No. 3, p. 85 (May/June 1973).

Key words: optics; research at NBS.

Introduction to a series of papers describing optics research at NBS.

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